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# Distributed Training Technology Project:
## Final Report

C. Douglas Wetzel

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13. ABSTRACT *(Maximum 200 words)*

The objective of the Distributed Training Technology project was to extend the use of videoteletraining (VTT) beyond lecture-based courses traditionally given by VTT to courses with interactive or hands-on laboratory environments. Lessons learned and guidelines resulting from the effort were derived for this final project report. The project formally evaluated the feasibility of using VTT to deliver training in four course content areas representing different challenges for VTT: Celestial Navigation, Navy Leadership, Fiber Optic Cable Repair, and a computer laboratory in a Quality Assurance course. A combination of three approaches has the greatest generality for implementing VTT laboratory courses: (1) students can be better prepared prior to performing laboratory work, (2) support at the remote site can be increased by providing a surrogate for the instructor in order to supervise students and conduct laboratory activities, and (3) video technology can be used to increase the visibility of activities between sites. An increased level of effort is required to convert and deliver VTT laboratory courses. Training equipment adapted for portability allows classrooms to be used by other VTT courses. Courses must be selected for student throughput sufficient to provide savings in travel costs.

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# Foreword

This report describes research conducted as part of the Navy Personnel Research and Development Center's Distributed Training Technology (DTT) project. The DTT project is part of our Classroom and Afloat Training research program and falls under the Education and Training project (L1772) of the Navy's Manpower, Personnel, and Training Advanced Development Program Element (0603707N). The work was performed under the sponsorship of the Bureau of Naval Personnel.

The research evaluated training strategies and technologies to extend videoteletraining (VTT) beyond traditional, lecture-based courses. The findings have direct implications for the design of future distance education systems in the Navy and elsewhere.

The recommendations in this report are intended for use by the Chief of Naval Education and Training and the Chief of Naval Personnel in developing policy for the application of VTT in the Navy.

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# Summary


## Problem and Background

Many Navy personnel requiring training are geographically separated from training resources. Videoteletraining (VTT) enables an instructor to teach multiple classes at different geographic locations. VTT has been an efficient and cost beneficial way to deliver training and is in operational use by the Chief of Naval Education and Training (CNET) within the CNET Electronic Schoolhouse Network (CESN). VTT has been used for lecture-based instruction and additional cost savings could be achieved by delivering other types of content, such as courses with hands-on laboratories or learning environments that are highly interactive.

## Objective

The objective of the Distributed Training Technology project was to evaluate and develop training strategies and technologies to extend the use of videoteletraining (VTT) beyond lecture-based instruction to courses with interactive or hands-on laboratory environments.

## Approach

The project objective was addressed by conducting work in three areas: (1) a laboratory was developed at the Fleet Training Center San Diego as a prototype classroom containing new VTT technologies; (2) experimental studies were conducted to evaluate the feasibility of using VTT to deliver selected courses with nontraditional types of content; and (3) lessons learned and guidelines resulting from the effort were derived.

## Results and Conclusions

Formal evaluations of the feasibility of using VTT to deliver training were conducted in four nontraditional course content areas that represented different challenges for VTT.

1. A Celestial Navigation course was successfully adapted for delivery by VTT. The course contained hands-on laboratories involving difficult computations and plotting. Detailed visuals of nautical tables were adapted and plotting was scored at remote sites with aids that captured the expertise of the instructors. Performance on a practical final examination was 4 percent lower for remote site than local site students.

2. Navy Leadership (NAVLEAD) training was delivered by VTT in two studies that evaluated three courses. There was some reduction in student interaction and participation in VTT classes, which is considered a valuable feature of the training. However, no decrement was found on measures of student performance and knowledge.

3. A Fiber Optic Cable Repair course was experimentally delivered by VTT. The course contained several hands-on laboratories on connector repair and trouble-shooting. It was instructionally feasible to deliver the course by VTT. Remote students performed as well as local students. However, extra course conversion and support efforts were required to deliver the training. A facilitator was needed to supervise all laboratory activities. The small number of

students per class offered marginal travel savings. Enhanced preparation of students prior to laboratories was used to offset the reduced assistance available from the instructor.

4. A Quality Assurance (QA) course with a student computer laboratory was successfully delivered by VTT from San Diego to remote students in Pearl Harbor. Existing VTT classrooms were accommodated by using portable laptop computers and a wireless network that avoided a clutter of cabling. Remote student performance was not impaired.

Lessons learned from the project include suggested VTT delivery approaches and an evaluation of feasibility, effort, and cost factors. A combination of three approaches can be used for delivering laboratory courses by VTT: (1) students can be better prepared for performing laboratory work prior to the laboratory, (2) support at the remote site can be increased by providing a surrogate for the instructor in order to supervise students and assist with laboratory activities, and (3) technology can be used to increase the visibility of activities between sites.

1. Preparation and Aiding: There are several ways to better prepare, assist, or augment students for conducting their own laboratory work with less support from the instructor. These include: (a) enhance lectures and demonstrations given prior to the laboratories, (b) present additional instruction prior to laboratories by videotape or by computer-based instruction, and (c) provide a job performance aid to assist students during the laboratory. These strategies compensate for the physical absence of an instructor who normally circulates among students in traditional laboratories to monitor progress and provide interactive forms of instruction.

2. Facilitator, Site Support Logistics, and Portability: The VTT facilitator plays an important behavioral, technical, and logistical role in laboratory courses. Many laboratories would require a facilitator to be present to assist students and to act as an agent of the instructor. Some laboratories would require a safety monitor. CESN facilitators for laboratory courses may have to become more knowledgeable of subject matter than is currently the case. There would be somewhat greater logistical demands on both local and remote sites to deliver laboratories by VTT, such as for setting up course equipment, storage, and maintaining supplies. Laboratories require flexible physical arrangements and additional space within VTT classrooms. Laboratory training equipment must be adapted to be portable so that it can be taken in and out of classrooms that are also used by other VTT courses.

3. Use of Technology as an Aid: Several themes are illustrated in the use of technology to support laboratory and lecture-based instruction: (a) increase the visibility of activities among sites, such as to provide a remote presence for the instructor; (b) use technologies to assist students during laboratories or to better prepare students for laboratories; and (c) reduce demands on the instructor with the aid of automated technologies, such as those that avoid the need for a camera operator.

Feasibility, Effort, and Costs: It is feasible to use VTT to deliver a range of courses that fall between traditional lecture courses and those laboratory courses that are prohibitive to deliver because of physical, safety, supervision, and cost requirements. Mild forms of laboratory courses could be delivered by VTT with little inconvenience to the CESN (e.g., the Celestial Navigation and Quality Assurance courses). Other courses, representing a moderate level of difficulty, are also feasible to deliver if greater effort is devoted to convert and support the delivery of the course. These courses require more effort in adapting materials and equipment, require duplicate training equipment and additional technology for remote sites, and require that more attention be devoted to deliver the course with greater assistance from semi-skilled facilitators at remote sites (e.g., the Fiber Optic course). The characteristics of these different levels of difficulty are developed within the report. Cost considerations for laboratory courses include the expense of duplicating equipment at remote sites and student throughput. Laboratory courses with a small number of students would provide marginal savings in avoided travel costs when delivered by VTT.

**Recommendations**

The following recommendations are for the Chief of Naval Education and Training, and the CNET Electronic Schoolhouse Network.

1. The lessons learned documented in this report should be provided as background material for use in adapting laboratory courses to VTT.

2. The approach to delivering laboratory courses by VTT should include enhanced preparation of students prior to conducting their laboratory work, technology that increases the visibility of activities between sites, and supervision by a VTT facilitator in remote-site laboratories.

# Contents

# Introduction

## Problem

Many Navy personnel who must receive training are geographically separated from training resources. An increasingly efficient approach to meeting this requirement is needed as the Navy downsizes and training resources become constrained. Videoteletraining (VTT) has been found to be an efficient and cost beneficial way to address this issue because it enables a single instructor to teach multiple classes that are at different remote geographic locations. The Chief of Naval Education and Training (CNET) has VTT in operational use in the CNET Electronic Schoolhouse Network (CESN). This VTT system utilizes an interactive two-way video and audio television system that allows distant *remote site* students to participate in the instruction originating from a *local site* where other students are co-located with the instructor.

VTT has been used for the delivery of lecture-based instruction. Even with current VTT technology, there is some reduction in the quality of the audio and video as compared with live instruction (e.g., it reduces the visibility of personnel at different classroom locations and also reduces the ability of instructors and students to interact as they do in a traditional classroom). These constraints make it more difficult to conduct training which is not instructor centered, such as courses with hands-on laboratories or learning environments that are highly interactive. Significant travel or instructor costs could be avoided if such training could be delivered via VTT rather than in traditional classrooms. There has been little experience with delivering this training by VTT because of the challenge presented by laboratory activities when remote students are separated from the instructor. The development of new instructional strategies and technologies to address this problem would extend the use of VTT to courses containing laboratories.

## Objective

The objective of the Distributed Training Technology project was to evaluate and develop training strategies and technologies to extend the use of videoteletraining (VTT) beyond lecture-based instruction to courses with interactive or hands-on laboratory environments.

## Background

Previous research and development has demonstrated that VTT can be an efficient and cost beneficial method to deliver training to remote Navy personnel (Bailey, Sheppe, Hodak, Kruger, & Smith, 1989; Barry & Runyan, 1995; Rupinski & Stoloff, 1990; Rupinski, 1991; Simpson, Pugh, & Parchman, 1990, 1991a, 1991b, 1992, 1993; Stoloff, 1991; Wetzel, Radtke, & Stern, 1993, 1994). This research on the use of VTT in Navy training has shown that typical lecture-based courses can be delivered by VTT without detrimental effects on achievement. Prior research on instructional television also indicates that student achievement is not affected by this method of delivery and that any initial unfavorable attitudes lessen as a result of experience with the medium (Wetzel, et al., 1993, 1994). The present project extends the research and development conducted in two previous NPRDC projects on adapting instructional content for delivery by VTT or video media.[1]

The major cost benefits of video teletraining systems are in circumstances where travel, per diem, or duplicated instructor costs are avoided by usage that is intense enough to offset the costs of the technology. Courses that are particularly beneficial in reducing travel costs are those with a high student throughput and which are short in duration (a week or less). Cost and efficiency benefits have resulted from use of the VTT system implemented in the CESN. Historical cost data maintained by the CESN from 1989 through the present indicate that the system reaches the break-even point approximately half way through a year (i.e., VTT system costs are approximately half the costs that are estimated to have been avoided for training and travel costs and those for conferences).

The possibility of using VTT for a wider range of courses would extend the cost and efficiency benefits of VTT beyond the lecture-based courses that are typically delivered by VTT. A substantial amount of Navy technical training involves a range of activities that extend beyond lectures. Surveys conducted in the mid 1980s showed that training administrators identified some form of laboratory in as many as three fourths of their courses. Training objectives involving procedural learning were also found to be the most frequent objective beyond those involving basic factual information (Wetzel, Van Kekerix, & Wulfeck, 1987a, 1987b).

There has been little experience with using VTT to deliver a variety of courses with hands-on laboratories or with highly interactive learning environments. These activities are more challenging when the pattern of communication departs from that in lecture-based instruction where information primarily flows from the instructor to the students. VTT technology constrains the ability of the instructor and remote students to hear and see one another more than it does for local students who are with the instructor. Laboratory courses are more difficult to conduct by VTT because the instructor and students are not physically present together when individual laboratory activities are performed. This restricts the face to face nature of the instruction when there is significant interaction, such as in Navy leadership training or in many other laboratories. Instructors normally perform several functions during laboratory courses as a consequence of their ability to circulate among students. These involve supervising and overseeing the activities of students during laboratories and providing students with assistance and guidance. This interactive form of instruction is present in courses that involve a wide variety of hands-on activities with equipment or in learning computer skills. These problems were addressed by conducting research on new instructional strategies and technologies that would allow these forms of laboratory instruction to be delivered by VTT.

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[1]These two Exploratory Development projects were funded by the Office of Naval Research Program Element 0602233N (Training Technology Project Numbers RM33T23.02 and RM33T23.03). The Communication Networks in Training project conducted initial experimental work on the feasibility of using VTT in Navy training, compared alternative audio-video strategies, and developed VTT course conversion guidelines (Pugh, Parchman, & Simpson 1991, 1992; Simpson, et. al., 1990, 1991a, 1991b, 1992, 1993; Simpson, 1993). The Videographic Interface Technology project contributed an extensive review of the effectiveness of learning from a variety of video-based media (Wetzel, et. al., 1993, 1994).

## Project Approach and Products

The objective of extending the range of courses that could be delivered by VTT was addressed by conducting work in three areas: (1) a VTT laboratory classroom was developed at the Fleet Training Center San Diego as a prototype VTT classroom containing new VTT technologies, (2) selected courses were converted to VTT and evaluation and experimental studies were conducted on the feasibility of delivering these courses by VTT, and (3) the methods developed and lessons learned from the effort were used to develop VTT guidelines documented in this report.

The major products from the project are described below. The remainder of the report summarizes the results of the experimental studies, the technologies explored during the research, and the lessons learned from the project. The courses evaluated were deliberately selected to represent a range of different problems that challenged the VTT medium. These included two courses with hands-on student laboratories, a course with a computer laboratory, and Navy leadership training courses involving highly interactive content.

The products resulting from this project include courses converted to VTT, technical reports documenting the feasibility of delivering selected courses by VTT, videotapes, software, hardware, and the lessons learned from the project documented within the present report. The major products of the project are as follows.

- Evaluations of the feasibility of delivering Navy leadership (NAVLEAD) training by VTT were conducted in three courses. This work was documented in two technical reports (Simpson, Wetzel, & Pugh, 1995; Wetzel, Simpson, & Seymour, 1995).

- A Celestial Navigation course was converted to VTT and an evaluation of the course was documented in a technical report (Wetzel, 1995).

- A Fiber Optic Cable Repair course was experimentally converted to VTT and documented in a technical report (Wetzel, Radtke, Parchman, & Seymour, 1996). Several other products resulted from this work. Three training videotapes on fiber optic cable repair were produced: (1) "The ST Connector," (2) "The Rotary Mechanical Splice Connector," and (3) "The Veam backshell and Hughes Connector." Fiber optic cable systems used in the course were adapted to be portable by installing them on four roll-away equipment carts. A video microscope was developed to allow student connector repair work to be shown over the VTT system. Computer-based instruction on fiber optic system trouble-shooting was developed.

- A Quality Assurance (QA) course was converted to VTT and an evaluation of the converted course was conducted (Wetzel, Pugh, Van Matre, & Parchman, 1996). A system of laptop computers with a wireless local area network was developed so that the course could be conducted within existing CESN classroom facilities.

- A videotape was developed for training new VTT instructors in the CESN. The 21 minute videotape "Videoteletraining Instructor Training" covers three topics: preparing materials for VTT, coordinating with remote-sites, and instructor behaviors. An additional videotape was produced that contains selected scenes recorded from three of the courses studied: "Distributed Training Technology project: Scenes from courses adapted to videoteletraining."

- An experimental VTT laboratory classroom was developed at the Fleet Training Center (FTC) in San Diego to conduct the research. The VTT laboratory serves as a prototype classroom incorporating new technologies that were explored and which can be considered for use in other VTT classrooms in the CESN. The classroom and its equipment were turned over to the San Diego CESN site at the completion of the project. The various technologies in the laboratory are described later. The products for the Fiber Optic and QA courses were also transferred to those courses.

- This report is the final product of the project and it documents the lessons learned from the research. Other work during the course of the project contributed to these lessons learned. This included observations and analyses of other courses that were considered for potential conversion to VTT. The project also collaborated with the CESN to establish facilities when the initial VTT system was brought on-line in San Diego and provided consulting assistance with some initial course conversions.

## Course Evaluations

Formal evaluations were conducted with four types of courses that were delivered by VTT on either a regular basis or for an experimental evaluation of feasibility. These courses represented a spectrum of challenges consistent with the purpose of the project. These nontraditional types of course content involved highly interactive small group processes, hands-on laboratories, and the use of computers in VTT classrooms.

### Evaluation Research Design

The course evaluations compared three treatment groups: (1) traditional classrooms, (2) VTT local classrooms with an instructor and students, and (3) VTT remote classrooms where students were connected to the local classroom by a VTT system. The VTT system was a fully interactive two-way audio and two-way video system that transmitted digital video at 384 Kbps. Students used push-to-talk microphones to speak over the system. Remote classrooms were generally monitored by a VTT facilitator who was not a subject-matter expert in the content of the course.

The outcome measures (dependent variables) varied somewhat over the studies. These measures fell in three general categories: (1) student performance measured in terms of academic achievement on written tests, performance on procedural tasks, or observer ratings of student performance; (2) student or instructor questionnaire responses evaluating the training; and (3) an observer tally of student-instructor interaction or help and assistance given to students.

## Research Studies

The four research studies discussed below were conducted with a Celestial Navigation course, three Navy Leadership (NAVLEAD) courses, a Fiber Optic Cable Repair course, and a Quality Assurance course. Several other courses that were considered for delivery by VTT because of their challenging content are discussed later.

### Celestial Navigation Course

The feasibility of delivering a Celestial Navigation refresher course by video teletraining was evaluated in a study by Wetzel (1995). The course presented challenges for conversion to the VTT format because it contained features that departed from those found in the typical lecture-based course. The course used various visuals with detailed print from nautical tables, contained hands-on laboratories involving difficult computations and plotting, and there was a concern for assisting remote site students in resolving problems with computations.

The adaptation of the course required a concerted planning phase to address potential difficulties, revising visual materials, procuring remote site materials, developing new instructor behaviors appropriate to VTT, and developing support mechanisms at remote sites.

Three treatment groups were compared with a total of 279 students who were in traditional, VTT local, and VTT remote classrooms. The treatment groups were compared on student academic performance, student questionnaire responses, and an observer tally of instructor-student interaction.

**Performance.** Student academic performance was generally at a high level over three measures of performance. There were no significant differences among the treatment groups on homework during the week. There was a small but statistically significant decrement in final examination scores for remote students, but there was no significant difference between groups in the percentage of students passing the course. Final examination scores were lower at remote sites than at the local site by 4.4 percent for officer students and 5.1 percent for enlisted students. Statistically controlling final examination scores for inequities in student characteristics due to different enrollment patterns at the sites showed an adjusted mean difference of about 4 percent between local and remote sites when officer-enlisted and military seniority status were controlled.

**Student Evaluations.** Student responses on questionnaire rating items were higher for VTT local and traditional students than for VTT remote students. However, the magnitude of differences between groups was generally small. Ratings for all groups were generally high and in a positive direction, and the observed pattern was typical of that found in previous VTT research. The differences among groups were negligible for topics concerned with class participation, hearing and seeing the instruction, and instructor presentations. Remote students gave slightly lower ratings than local students on topics related to getting assistance or attention, but did not rate the difficulty or pace of the course significantly different. Remote students were more likely to agree that they had less access to and interaction with the instructor, and to identify other students as a source of assistance outside of class. However, remote and local students were equally willing to take another VTT course. VTT students were more accepting of the VTT method of instruction than were traditional students who had not experienced this method.

**Interaction.** An observer's tally of interactions during lectures indicated that there were adequate levels of remote site student participation and instructor interaction with remote students. Interactions were most commonly initiated by instructors with a mix of questions that were open to any site to answer, directed to a site, or directed to individual students identified from a roster. This mixture allowed the instructor to assess computational knowledge in students likely to respond when they knew an answer, as well as those individuals that were less likely to participate. There tended to be fewer interactions per hour associated with remote sites because there were fewer students than there were at the local site. However, remote students were not disadvantaged when these interactions were expressed in terms relative to the number of students (per student per hour). In these terms, remote site students received a higher rate of instructor questions associated with their site than did local students. After the first day of class, student initiated questions increased, unanswered instructor questions decreased, and instructor reminders for local site students to use their microphones declined.

**Technology Evaluations.** This study included two small evaluations of video technologies. One of these examined picture-in-picture (PIP) technology. PIP was found beneficial for showing both the instructor and his visuals (such as "strip form" work sheets) during periods when only the visuals and not the instructor would normally have been shown. The use of PIP was favored more by remote than local site students. VTT remote students gave higher ratings for the quality of the presentation with PIP. The difference between ratings of effectiveness with and without PIP was also larger for remote students. When asked for their preference, remote students overwhelmingly chose the presentation with PIP over the presentation without PIP. Local students were relatively neutral in their preference for PIP. This technique could be used for the outgoing video sent to remote students in other courses where an instructor might be off-screen for lengthy periods.

Another brief questionnaire was given to students that asked them to compare an electronic presentation program lesson with the conventional hand-written method used in other lessons. Students had no preference for one method or the other and gave the methods similar effectiveness and readability ratings. Thus, the choice of these technologies can be based on practical and efficiency factors.

**Discussion.** The Celestial Navigation refresher course was successfully adapted for delivery by video-teletraining. The course has been offered regularly to remote VTT sites without problem and is accepted by students and instructors. The initial concerns with the feasibility of delivering the course were overcome as a result of several course conversion techniques and the efforts of the instructors to monitor remote site students.

Several aspects of the adaptation of this course and its materials provide an illustrative example of a VTT conversion methodology applicable to other courses. Instructor transparencies typically must be revised to contain fewer lines and words, put in a landscape format with a consistent size, and reproduced on paper to avoid reflections. The approach to the visuals in this course addressed a problem with using video displays to show the many small print tables in nautical publications. Showing an entire table rendered the small print unreadable, while zooming in on relevant text lost the overall context of relevant column and row headings. Critical portions of the text were enlarged and arrows pointed to the location of these entries in the table so that students could locate the entries in their own publications. Lengthy "strip forms" used for a series of calculations were also enlarged and segmented into several pages. An important principle illustrated in this course was the development of scoring methods that captured the expertise of the instructors and allowed facilitators to act as an extension of the instructor. Facilitators were able to score student plotting on charts by using an acetate overlay marked with the correct course, fixes and labeling required of students. Although this was a relatively mild form of a laboratory course, student questionnaire responses revealed a facilities related issue applicable to laboratory situations. Students at some sites indicated that table space was more confined and this made it more difficult to use the four publications and various small items used in plotting. Such facilities concerns would likely be more severe in laboratory courses with more extensive equipment.

The success in delivering this course by videoteletraining allows its delivery to be expanded to other sites that originate instruction (e.g., an East coast CESN site). Experience with this course indicates that an adjustment in the frequency of VTT delivery can be balanced with enrollment demand at remote sites. The recommendations derived from delivering this training are applicable to other VTT laboratory courses. It was recommended that VTT courses with atypical requirements, such as student laboratories, should be given special attention to maintain a high quality VTT version of the course. Such attention includes monitoring remote-site student comprehension, conveying VTT "lessons learned" as remote site facilitators and instructors rotate in their assignments, and providing sufficient space for the additional instructional materials found in this and other future laboratory courses.

### Navy Leadership Courses

The objective of this evaluation was to test the feasibility of using VTT to deliver Navy leadership (NAVLEAD) training. This training represents a departure from the instructor-centered, lecture-based courses typically given by VTT because it involves high levels of instructor-student and student-student interaction. These courses involve a combination of lecture, discussion, and experiential learning activities, such as case studies, simulation exercises, and team work in small groups. One type of activity involves team members working together on assigned group problem-solving tasks that are subsequently reported to the class. The training is conducted by a team of instructors who facilitate interaction and the sharing of experiences as part of the learning process. Traditional classrooms are arranged so that instructors are able to stroll among tables in physical proximity to student groups. Nonverbal cues such as body language and facial expressions may be used to interpret student understanding and attitudes. There is a high demand for this training and the use of VTT would avoid instructor and student travel costs. The primary evaluation issue was whether the highly interactive instructional environment of the live classroom would be compromised by the lack of physical proximity of instructors and students trained by VTT.

The feasibility of using VTT to deliver Navy leadership training was tested in two studies with three courses. One study evaluated a Division Officer Basic Navy Leadership course with 105 students (Simpson, Wetzel, & Pugh, 1995). The other study evaluated Chief Petty Officer

(CPO) and Leading Petty Officer (LPO) courses with 192 students (Wetzel, Simpson, & Seymour, 1995).

The evaluations compared traditional, VTT local, and VTT remote treatment groups. Six evaluation measures were used: student evaluations of VTT, student evaluations on instructional topics, daily observer evaluations on several dimensions of the training, an interaction tally of class participation, observer evaluations of student performance on a simulated classroom activity (LPO and CPO only), and performance on an end-of-course multiple-choice knowledge test (DIVO only).

**Student Evaluations.** Student questionnaire responses tended to favor traditional instruction slightly more than VTT instruction. Rating item responses were on the positive end of the scale, and differences among the treatment groups were generally small or modest.

Little difference between local and remote sites was observed in either study on the questionnaire concerned with VTT topics (only VTT groups completed these items). Audiovisual factors typical of findings for other types of courses were the only significant rating differences observed in one study. Students did, however, express the opinion that VTT reduced their opportunities to interact with the instructor, and although they were somewhat divided in their preference for VTT, they indicated they would take another VTT class.

The questionnaire covering instructional issues revealed somewhat larger differences as a consequence of the wider range of treatment conditions that included VTT local, VTT remote, and traditional students. These differences were again modest, with the largest group differences appearing on topics that tended to be common to both evaluation studies (DIVO and LPO/CPO). The largest differences between groups in favor of traditional instruction were on topics related to seeing and hearing students, teams, and instructors; or on topics related to interaction and participation. Compared with the responses of DIVO students, larger treatment group differences were observed for the combined data of the LPO and CPO students. This larger difference was primarily due to CPO and not LPO students. CPO students gave lower ratings overall, were generally more critical, and were less accepting of VTT.

Student responses to open-ended questions were most often related to some aspect of the course content and interaction. Response rates were greater for what students liked than for what they disliked about the course. In general, about half of the comments were positive and a third negative. Remote students were more likely to respond on open-ended questions and were more likely to comment about VTT related problems.

**Observer Ratings.** Daily ratings by subject-matter experts on various dimensions of the training generally yielded the largest group differences observed in both studies. These observers gave higher ratings to traditional instruction than VTT, and the pattern was generally the same over the week so that VTT courses did not reach parity with traditional courses. Observers rated VTT lower on effectiveness, interaction, and control over the class, and rated the difficulty of conducting the instruction as greater. There was a general tendency for interaction and participation to have been rated as increasing over the early part of the week. A recommended technique to foster such interaction is to get students actively using a VTT system early on the first day of a course.

**Interaction Tally.** The tally of student initiated questions and comments represents a behavioral measure of student interaction and participation that is more objective than the ratings above. The general pattern across all classes in both studies indicated a similar level of interaction for traditional and VTT local classes, while VTT remote classes were on average about two thirds this level. About a third of the individual VTT remote classes fell below the lowest level of local and traditional classes. Thus, some remote sites interacted at a somewhat lower level, and the observed data suggest that some variability should be expected from class to class and instructor to instructor.

**Student Performance and Knowledge.** Each of the two studies contributed a different measure that assessed an aspect of student performance or knowledge. These aspects were assessed near the end of the course where they would be expected to reflect student learning during the training.

Several dimensions of student performance during a classroom simulation activity were assessed by instructor/observer ratings in the evaluation of the LPO and CPO courses. No statistically significant differences were found among the three treatment groups on any of the ratings for either LPOs or CPOs. There was a trend for the VTT remote students to be rated somewhat lower on a few items. The results suggested that VTT had little effect on student performance. This performance was assessed on a specific task that was more behaviorally focused in nature than the other more general ratings made by observers at the end of each day.

Student knowledge was assessed at the end of the Division Officer course with a multiple-choice quiz that covered course content. Traditional, VTT local and VTT remote students showed identical levels knowledge of course content.

**Discussion.** The feasibility of using VTT for Navy leadership training was demonstrated in the sense that the classes were conducted successfully, students received training and graduated, and there was no significant outcry about the way their training was being received. However, adapting the instruction to delivery by VTT may have led to some changes in areas that have been held to be important in the Navy leadership community: the intensity of a learning environment involving instructor-student and student-student interaction was lessened, the ability of instructors to circulate among teams and to perceive remote students' nonverbal cues was limited by the view offered through the VTT system, and some experiential learning experiences were more difficult to conduct with VTT.

Based on the subject-matter expert ratings and the data pertaining to participation, some reduction in the interactivity of the NAVLEAD learning environment was suggested for VTT classes as compared with traditional classes. On the other hand, it was not clear that the course had been compromised and several other considerations may play in the decision to offer the training by VTT. First, some of the observed significant differences between VTT and traditional NAVLEAD courses mainly reflect perceptions of reduced quality among ratings that were generally on the positive end of the scale. Among the more objective measures, the interaction count was nonetheless lower by about a third, but two instances reflecting learning were not affected. Second, this research involved the first attempts to deliver NAVLEAD instruction by VTT and the training has not been offered in this way on a regular basis. Regular delivery of these courses by VTT would likely lead to some improvements as more experience is gained with VTT and instructors develop new techniques to foster interaction. Evolving new instructional strategies and instructor behaviors to encourage greater student participation could also be supplemented with new video technologies to show better views of individuals between sites. Compared to when sites participate together as a whole class, the ability of instructors to monitor the audio and video of activities involving multiple small groups at remote sites appears to be the greatest challenge in this course.

A decision to use VTT for NAVLEAD involves weighing potential cost savings against the modest reduction in interactivity associated with using VTT for the training. There is a strong demand for NAVLEAD training and significant travel or instructor costs could be avoided if such training could be delivered by VTT. If a decision were made to conduct NAVLEAD instruction with VTT, ways to foster higher levels of interaction should be tested and refined.

### Fiber Optic Cable Repair Course

The feasibility of using VTT to deliver a Fiber Optic Cable Repair course was evaluated in a study by Wetzel, Radtke, Parchman, and Seymour (1996). This course was selected as a representative of challenging hands-on laboratory courses. The course contained a range of activities that included instructor demonstrations and student laboratories for three types of fiber optic connectors, the use of test equipment, and a hands-on performance test.

Three treatment groups were compared with a total of 50 students in traditional, VTT local, and VTT remote classrooms. The VTT local and remote conditions were simulated in the sense that students were located within the same building in different classrooms. A second instructor served as a VTT facilitator to monitor the VTT remote students for safety reasons during VTT classes. The groups were compared on procedural errors during connector laboratories, a trouble-shooting performance test on faulted fiber optic systems, help received during laboratories, final examination scores, student questionnaire responses, and an observer tally of interaction over the VTT network.

**Performance.** There were no significant group differences in student performance indicating impairment for remote site students as a consequence of delivering the course by VTT.

Procedural errors during two connector repair laboratories were no higher for remote students compared to either local or traditional students. Errors declined about 20 percent during the second laboratory, suggesting that student performance improved with experience. There were no significant group differences on observer ratings of safety, the quality of student work, or objective light loss readings for the connectors. About 6-7 percent of all students received the lowest rating on wearing eye glasses and controlling fiber fragments. There was a slight trend for more instances of help and assistance for remote students and for them to aid one another more than the other groups. A video microscope used to show connector ends over the VTT system was found beneficial in allowing remote site student work to be inspected by the instructor and for other students to observe examples of acceptable and unacceptable work.

Trouble-shooting test performance on faulted fiber optic systems also revealed no significant differences between the treatment groups. The groups had similar success in finding a fault and they listed a similar number of possible fault causes and corrective actions. Students required less help and less time to solve the fault on the second of two test systems and this improvement was slightly less pronounced for remote students. Help given to students during the performance test predominately concerned trouble-shooting logic, followed by help on test equipment. The fiber optic systems were installed on roll-away carts, illustrating the adaptation of equipment to be portable so it can be taken in and out of VTT classrooms that are used for other courses.

Remote-site students generally required slightly more time to complete the various laboratory periods than did the other groups. This might reflect logistical delays in establishing communications over the system or the absence of an instructor who is immediately available for assistance or supervision. Scores on a final multiple-choice test did not differ significantly between groups and there is typically little decrement for remote students on such lecture-based material.

**Interaction and Student Evaluations.** A tally of instructor-student interactions across the network indicated little disadvantage for remote-site students during lectures and demonstrations when students participated as a combined class. During laboratories when students worked individually or in small groups, the network was used primarily by remote students to ask questions of the instructor. Student questionnaire responses revealed few significant differences between the treatment groups. The groups did not differ in their perceptions that some course activities were more difficult to conduct than others. Most VTT students indicated that they would take another VTT course. They also were more accepting of the VTT method of instruction than were traditional students who had not experienced this method.

**Discussion.** It was instructionally feasible to deliver the Fiber Optic course by VTT based on the results of the experimental test run. Enhanced preparation of remote students prior to performing their laboratory work was identified as a method to offset the reduced assistance available to students who are at a distance from the instructor. Examples of this preparation in this study included the use of three videotapes on connector repair, computer-based instruction on trouble-shooting, and moving topics taught during laboratories into lectures and demonstrations given prior to conducting laboratories. Other technologies were used during laboratories to support instructors and students. These included portable cameras used for instructor demonstrations (e.g., with preset pan/tilt/zoom setting to allow the instructor to demonstrate test equipment without need for a supporting camera person), a microphone-based video switching system to show individual student work stations when students asked questions, the video microscope to show connector ends over the system, and the general use of methods that permitted portability (e.g., portable roll-away fiber optic system carts created to allow the course to be delivered outside the traditional laboratory).

Although the evaluation showed that it was feasible to deliver the course by VTT, the conversion and delivery of the course involved a moderate amount of difficulty. Substantial preparation to accommodate the use of course equipment and the development of compensatory techniques were required to convert the course for VTT delivery. Delivery of this course by VTT would increase demands on VTT site personnel and would involve additional room preparation and support logistics. A VTT facilitator would need to be present during student laboratories as a safety monitor and to assist the students and instructor. Offering the course by

VTT would offer marginal travel cost savings because of the small numbers of students per class, although other laboratory courses with greater throughput could be beneficial.

**Quality Assurance Course**

The feasibility of using VTT to deliver a course with a student computer laboratory was evaluated in a study by Wetzel, Pugh, Van Matre, and Parchman (1996). A 3 day Quality Assurance (QA) course was selected because it contained a hands-on computer laboratory and the course had sufficient student throughput to warrant the VTT conversion efforts. The course is primarily lecture-based, with heavy emphasis on correct use of reference materials to fill out QA forms. Several laboratory sessions involve filling out various paper-based forms and a 2 hour laboratory requires the use of a computer to create a printed document. Students produce a Control Work Package (CWP) document during the laboratory with a CWP computer program designed for this purpose. Students use the CWP program to enter data that will be printed in blocks on the document and to enter paragraphs for narrative sections of the report.

**Approach.** The primary elements of the VTT approach to this course involved: (1) a portable computer system using a wireless network, (2) demonstrating QA software over the VTT system via a video scan converter, (3) enhanced preparation of students prior to the computer laboratory, and (4) use of an existing computer classroom at the local site so that new equipment was primarily needed only for a remote site.

Conversion of the course to VTT involved the adaptation of course materials and training instructors in VTT delivery techniques. Instructor presentation materials were converted to a landscape hard copy form and revisions were made to enhance the quality of numerous visuals. High quality still photographs of a mechanical valve were created so that identification marks inscribed on the valve could be seen in demonstrations presented over the VTT system. A demonstration of the computer program, accompanied by a discussion of useful operation tips, was added prior to conducting the student computer laboratory. A phased approach was used to tryout and refine the delivery of the course. Instructors first practiced using the VTT system and then used the computers in a simulated local-remote environment. Several dry-run courses were conducted with simulated remote students who were located in a VTT classroom adjacent to that of the instructor. This permitted instructors to practice using the VTT system and allowed the lectures and demonstrations to be refined. The course then went on-line with actual remote students located in Pearl Harbor, Hawaii. The local (originating) classroom was located in San Diego.

Laptop computers were used at the remote site because they are portable and can be moved in and out of VTT classrooms that must be used for other VTT courses. This avoided having to dedicate the rooms to computer laboratories with larger equipment that requires more space and results in fewer seats. An infrared wireless local area network (LAN) was used with the laptop computers to reduce a clutter of wiring in the room. The wireless LAN allowed students to print their work on a laser printer that was attached to a personal computer server.

A scan converter was used so that computer screens could be transmitted as video over the VTT system. The scan converter allowed the instructor to demonstrate the operation of the computer program to students prior to conducting the laboratory. Although the resolution provided by the scan converter was less than that of the computer display, it was sufficient to provide general orientation and to show the sequence of operations when accompanied by the instructor's verbal description. The capability also allowed the instructor to answer student questions on operating the program during the laboratory. The instructor would locate the particular point in the program where the student was encountering difficulties and show that screen over the VTT system. Thus, the difficulty of an exclusively verbal exchange was reduced because both participants were viewing the same screen.

With the exception of the computer laboratory, both local and remote students received all instruction in the VTT classrooms. VTT local students left the VTT classroom during the computer laboratory and used an existing computer laboratory in another building at FTC San Diego. Remote students remained in the remote VTT classroom at Pearl Harbor during the computer laboratory. One of two QA instructors accompanied the local students to their laboratory while the other instructor remained in the local classroom to monitor remote students over the VTT system. A VTT facilitator was available at the remote site to assist students. A pair of students shared a laptop computer if there were too many students to allow individual use of a computer.

**Evaluation Results.** The course evaluation compared VTT local and VTT remote treatment groups with a total of 100 students. Evaluation measures consisted of performance on an objective 50 item final examination, an experimental 10 item quiz on facts about the computer program, a student questionnaire, and an observer tally of student-instructor interaction over the VTT network.

There were no significant differences between local and remote students on the end-of-course final examination on various aspects of the QA process. These scores were also comparable to those for 133 students who had previously received instruction in traditional classrooms. There was no significant difference between the local and remote students on the quiz covering facts about operating the computer program in the laboratory.

Student questionnaire responses generally showed few differences between the local and remote students. Significant differences between the groups were found in three topic areas. First, the visibility of instructional materials and training aids was rated slightly lower by remote than by local students. Second, access to, or attention from, the instructor was rated lower by remote students. Local students were more likely to cite the instructor as a frequent source of assistance, whereas remote students cited assistance from a combination of the instructor, VTT facilitator, and other students. Third, a group of questions indicated slightly greater problems for remote than for local students on aspects of the computer laboratory (i.e., operating the computer program and printing documents). However, the average difficulty ratings of remote students were in a positive direction and slightly above the portion of the scale indicating "few" problems (i.e., rating were on a scale ordered in terms of "no," "few," "some," and "many" problems). Remote and local students indicated a similar acceptance of VTT as a method of instruction on other questionnaire items.

The tally of interactions over the VTT network showed that instructor initiated questions during lectures were many times greater than when students were engaged in performing laboratory activities. Remote students initiated interactions less than local students, but remote students participated equally when instructor questions identified a site or student that should respond.

A cost analysis was conducted for the anticipated use of the computer equipment used in this research at two remote sites located in Pearl Harbor, HI, and Bangor, WA. Avoided travel costs to San Diego for 10 students from each of these two sites were compared with the costs of delivering the laboratory course by VTT. Avoided student travel costs for four class convenings were estimated to be $15,504 in excess of the VTT delivery costs (i.e., travel costs minus the sum of VTT classroom contract costs plus amortized computer costs). Additional course convenings where other courses share the same computers would reduce the impact of the costs for outfitting VTT remote sites.

**Discussion.** The experimental implementation of the QA course computer laboratory was successful. Remote students performed as well as local students on the final examination and on the computer operation quiz. The student evaluation questionnaire showed little difference between the groups. The judgement of the instructional staff and researchers was that it was feasible to deliver the course in this manner. The implementation of this course could be expanded to other sites and the portable computer technique could be used in other courses with similar requirements. However, it should be noted that the QA course involves a mild form of a hands-on laboratory in the sense that the computer laboratory is not long, the task is not difficult, and students could perform the task without extensive instructor assistance. As with the Fiber Optic Cable Repair course, progressive enhancements made to instructor demonstrations illustrated the technique of better preparing students for conducting their laboratory work with less assistance.

## Delivering Laboratory Courses by VTT

This section presents considerations applicable to delivering laboratory courses by VTT according to the following topical organization: (1) a review of general conversion methods for VTT courses that emphasizes a systematic approach, (2) discussion of approaches and lessons learned for delivering laboratory courses, and (3) identification of the several characteristics of training that are related to the degree of difficulty in converting or delivering instruction by VTT. The final section of the report presents a series of general guidelines derived from this discussion.

### VTT Course Conversion Methodology

Simpson (1993) developed a guide to converting Navy courses to VTT that is generally applicable to both lecture and laboratory instruction. A slightly modified version of this methodology is outlined below because it has value as a systematic approach with several important elements that could be overlooked without previous experience in VTT course conversion. Additional considerations applicable to converting laboratory courses are discussed later. These considerations are elaborations of the analysis and redesign steps given below. The methods for laboratory courses involve significant problem solving efforts, case by case consideration of specific problems, and experimentation to achieve the best approach. A new element reflecting cost considerations that could be associated with laboratory courses has been added to the initial steps given below.

**Course Conversion Steps**

1. **Form a Working Group.** Members of a working group should represent expertise in several areas: a training/education specialist, a subject-matter expert on the course to be converted, and an audio-visual or media specialist. Additional skills of benefit to the group would be prior experience in videoteletraining and training evaluation. The group should identify conversion tasks, define member roles and responsibilities, and set milestones.

2. **Observe Training and Collect Data.** The working group should have previously observed other VTT courses prior to collecting data on the course being proposed for conversion to VTT. The working group should observe the actual training course and systematically record data on the course activities. Observations of the course should include details on all course activities, such as instructor demonstration requirements, the type of interaction between instructor and students, the materials used by students, the media used by the instructor, testing, and the requirements of student laboratories. Data should be assembled to assess the estimated student throughput and costs of duplicating training equipment at remote sites.

3. **Analyze Training.** Based on the observations of the course, the working group performs an analysis to determine how the requirements of the instruction can be met when delivered by VTT. The constraints on delivering the training by VTT are identified and candidate solutions are developed. Instructor visual presentation materials to be converted are identified and scrutinized for visual detail and small print that cannot be supported by the resolution of video. Materials that will have to be procured or duplicated for the remote site are identified. Test administration, scoring, and reporting procedures are reviewed with respect to how they will be performed at remote sites. Lectures, demonstrations, and laboratories should be analyzed for modifications that are required by specific training activities and for atypical communication or interaction needs. Functional areas used within the classroom are identified that may have to be duplicated in new ways within the VTT classroom. Demonstrations involving large or difficult to see items are identified and alternative procedures or training aids are proposed. The assistance that will have to be provided by remote site facilitators is identified. For laboratory courses, alternative ways must be devised to supervise students and to provide the assistance to students that would normally require the physical presence of an instructor. As described later, a cost analysis should be conducted at this point to determine if there is sufficient student throughput to warrant a conversion of the course to VTT.

4. **Redesign and Convert Training.** The best candidate solutions from the analysis of the course are used to convert and redesign the training for delivery by VTT. Simplicity and fidelity with the original traditional training are design goals in developing the compensations required by the constraints of VTT. Materials required for remote sites are procured and remote site testing and scoring procedures are developed. Training materials are converted to hard copy form in a landscape format for presentations on a video document camera. New simplified graphics are created as appropriate to the lower resolution of the video medium. Training aids are revised or new ones are created. New instructional delivery or demonstration techniques are developed. Demonstrations that contain aspects that are difficult to perform live can be videotaped in advance to provide the best views. All converted or redesigned materials and demonstrations should be tested over the VTT system to assess their visibility to remote observers. The classroom layout is modified to accommodate any extra space requirements for

demonstrations and for student work areas during laboratories. Techniques and technologies for supporting laboratory course activities are discussed later in this report.

5. **Train Instructors and Facilitators.** Instructors should observe other VTT classes, become familiar with the architecture of the VTT system and classroom equipment, try out converted instructional materials, and practice delivering instruction before observers in a VTT classroom. Suggested topics for instructor training are given in Simpson (1993), in relevant instructions maintained by the CESN, and in a training videotape for new instructors that was developed during this project (the tape covers converting instructional materials, instructor behaviors, and coordinating with remote sites). Coordination with the remote site should be initiated and course procedures should be reviewed with remote site facilitators. A daily list of course events should be created which specifies when materials are to be distributed, when tests are to be given, and the procedures for scoring tests.

6. **Implement and Refine Training.** An initial pilot course is conducted with actual students. Instructor techniques and converted materials can then be revised based on this experience and critiques from observers. All modifications to the training should be documented at the time that the course goes on-line. The training should be formally evaluated after implementation in terms of student achievement and the observations or comments provided by students, remote site facilitators, subject-matter experts, and training specialists. Experience in actually delivering the course should be used to refine the training by repeating portions of the earlier analysis and redesign steps. A subsequent evaluation after a lengthy period of implementation would also be recommended to assess whether any undesirable drift in training procedures has occurred.

### Cost Analysis

Delivering laboratory courses by VTT could involve cost issues that are not found with lecture-based VTT courses. Some laboratory courses may have fewer students than are found in typical lecture-based courses. Some laboratory courses may also require expensive equipment that would have to be duplicated at remote sites. Additionally, the number of students may be constrained by access to a limited amount of training equipment. These circumstances would require an analysis to ensure that offering the course by VTT would provide a cost benefit. Some value judgement may be required if the training is judged to be important because a skill is critical. The primary benefit of VTT is obtained when student travel and per diem costs are avoided because students do not travel and instead receive training near their duty station. A brief outline of methods to assess the benefit of VTT delivery is given below. It is based on first estimating student throughput and development costs, and then comparing the relative level of costs for avoided travel with those for using VTT.

**Estimating Student Throughput.** The estimated student throughput for a proposed course can be developed by: (a) examining historical data from course rosters to determine the extent to which previous students traveled to the proposed training delivery site, (b) examining data on student throughput at remote sites where a course might be eliminated, (c) estimating demand for students that would not otherwise take the training unless it were made available locally at a remote site. A brief survey of commands or ships might be conducted to estimate anticipated throughput for students who do not receive training because of the unavailability of travel funds.

The estimated student throughput for each remote VTT site is then used to develop an estimate of the avoided travel costs for a class convening. Avoided travel costs would typically be the product of the estimated student throughput and the sum of the round trip airfare, local travel, and per diem for the length of the class.

**Estimating Significant Development Costs.** Initial costs required to enable the capability to deliver training at a remote site may need to be considered if the expense is significant. These initial costs could be for training equipment that must be duplicated at the remote site. These initial costs could also be for unusual expenses required to develop new training aids or methods. If these initial costs appear to be significantly above what might be expected for a lecture course, then the costs can be included with the VTT delivery costs. These initial costs can be amortized over the expected life of the training equipment or the life of the VTT training course. For example, if the expected lifetime were 5 years, the yearly costs computed for a course would be increased by an amount equal to one fifth the initial training equipment costs. An example of an analysis incorporating amortized initial costs is given in Wetzel, et al. (1996) for the computers required to deliver the QA course by VTT.

**Judging VTT Delivery Benefit.** Several alternative approaches can be considered for determining the benefit of offering a course by VTT.

*Parity with Average Throughput:* If development and equipment costs are negligible, then student throughput is the primary consideration in deciding to offer a course by VTT. Delivering the training by VTT would likely be beneficial if the estimated throughput were at least the average throughput found in the CESN. This average has historically been between 10 and 11 students per classroom, based on an average of about three participating sites. This range has typically been used as a minimum by the CESN for considering whether to deliver courses by VTT. Using this average as a criterion reflects the assumption that the level of throughput for the CESN has been successful in generating a cost avoidance in excess of the costs of maintaining the VTT system.[2] The benefit of operating this VTT system reflects a combination of courses that vary in throughput, where some high throughput courses compensate for others with lower throughput, as well as ancillary use of the system for conferences.

*Student Travel versus VTT Classroom Costs.* A successful use of VTT would be suggested if the costs avoided for student travel exceed the costs for using the VTT system. This method reflects the current costs for operating the VTT system and is in effect a miniature version of the cost comparison made for the CESN as a whole. The following analysis might be performed in

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[2]Estimated costs in the historical record of the CESN from 13 March 1989 through 30 September 1995 indicate a total VTT system contract cost of $5,164,456 and total avoided travel costs of $9,174,332 ($7,108,424 training costs and $2,065,908 conference costs). Thus, the contract costs are about 56 percent of the estimated avoided costs, which leads to the statement that operation of the system breaks even about half way through a year. Excluding the ancillary use of the system for conferences, the contract costs are about 73 percent of the estimated avoided training travel costs. An early cost analysis of the CESN is given in Stoloff (1991).

situations where no instructor exists at remote sites and student travel would be required to obtain the training.

The costs of the VTT delivery method for one class convening would be the current CESN contract costs for the number of VTT classrooms to be used for the duration of the class. The daily cost of the VTT classrooms would be the sum of the yearly contract costs for the local and remote classrooms participating in the training divided by the available training days per year. The per convening cost of a class would be the daily cost of the VTT classrooms times the number of class days for the convening. Any significant initial fixed costs for equipment or development would be added to the per convening cost for each of the remote sites (i.e., amortized fixed costs per year divided by the number of class convenings).

The estimated throughput per class convening is used to develop an estimated travel avoidance. The throughput could reflect prior actual student travel and that resulting from the training opportunity at the remote sites that represents travel that would have been expended were funds available. Round trip airfare, per diem for the duration of the training, and local travel costs for the anticipated number of students at each site would be summed for all of the remote sites.

The estimated cost avoidance for travel and per diem for the remote sites would then be compared to the VTT classroom costs for the class convening.[3] A beneficial use of VTT would be suggested to the extent that estimated student throughput generates avoided student travel costs that exceed the cost of using the VTT classrooms. The per year costs would be the product of these per convening costs and the number of convening. To achieve parity with the previously noted historical benefit obtained by the CESN for training (excluding conferencing), the costs of using VTT would have to be about three fourths of the estimated avoided travel costs.

In some circumstances there may be an opportunity to use VTT to centralize the delivery of training and reduce the number of instructors duplicated at more than one site. However, the benefit may depend somewhat on the details of a particular course and the perspective that is

[3]For example, assuming $70,000 as the average cost of a CESN classroom and 251 available training days a year, the daily cost of one classroom is $279. The VTT classroom convening costs for a local and one remote classroom would be $1,674 for 3 days and $2,790 for 5 days. If a second remote site is added to these, the total is $2,511 for 3 days and $4,185 for 5 days. Avoided per student travel costs for a 3 day class convening with round trip airfare of $76 (Government rate between San Diego and San Francisco), local travel of $20, and 4 days of per diem at $25 per day would be a total of $196, and for a 5 day convening would be a total of $246. Assuming 10 students for one remote site, avoided student travel would be $1,960 for a 3 day class and $2,460 for a 5 day class. If a second 10-student remote site with the same airfare were added, avoided student travel would be $3,920 for the 3 day class and $4,920 for the 5 day class. Comparing the avoided travel costs with the cost for using the VTT classrooms, one remote site generates avoided travel sufficient to exceed the cost of the two VTT rooms for a 3 day course ($1,960 vs. $1,674), but not for a 5 day course ($2,460 vs. $2,790). However, the addition of a second remote site (1 local and 2 remotes) generates avoided student travel in excess of the VTT classroom costs for class convenings of both 3 days ($3,920 vs. $2,511) and 5 days ($4,920 vs. $4,185). Thus, an extra VTT remote site provides the advantage of generating additional travel avoidance and minimizes the impact of the local classroom costs where there are no avoided travel costs. Fewer students would reduce the travel avoidance without affecting the VTT classroom costs. Additionally, shorter class convenings have a relative advantage because room costs are proportionately less, while travel avoidances are only slightly reduced by the days of per diem.

taken. From the perspective of a remote site that delivers training, eliminating a duplicated instructor might be a benefit if that resource continued to be available locally and could be used in another way. A local command would benefit by reassigning an instructor when the cost of the VTT system is funded from other than local sources. From the perspective of the entire Navy training enterprise, the costs for a duplicated instructor and the costs for the VTT system are alternative ways to provide the training. At this level, the costs are incurred either way and the two alternatives would be compared (e.g., costs for two instructors versus costs for one instructor plus the costs for the VTT classrooms involved). The least expensive alternative would have to be determined based on the details of the particular course, proportion of instructor time devoted, number of sites, and throughput. In those cases where the VTT system appeared to be beneficial, avoided travel costs would still be required to exceed the costs of the system.

## Approaches to Delivering Laboratories by VTT

In traditional laboratories, students are physically present with the instructor and may cluster around the instructor to view a demonstration. During student laboratories the instructor may circulate among students, look over their shoulders to observe progress, and deliver instruction as needed in an adaptive fashion. These interactive tutorials amplify details, clarify concepts, or provide the student with corrective guidance. This form of instruction may appear unplanned when students seek help, are observed to need help, and when conveyed through casual conversations. A related situation exists in laboratories where small group processes are involved. Proximity is also valuable when there is a high degree of interaction among participants and nonverbal cues are an important part of the communication.

This learning environment in traditional laboratories may need to be conveyed in different ways to provide the same information to VTT remote students who are not physically with the instructor. When remote students perform laboratory activities at a distance from the instructor they must use the VTT system to communicate with the instructor, rely on resources at their own site, or rely on prior instruction to work more independently.

### Possible Approach Alternatives

Several approaches can be considered for delivering courses that contain laboratories. A subset of these alternatives are more likely to be implemented as solutions. Other possible approaches are more applicable to specific circumstances or may be less acceptable in several respects.

Three approaches have the greatest generality and are more likely to be used to implement VTT laboratory courses. First, students can be better prepared for performing laboratory work prior to the laboratory or given aids to augment performance during the laboratory. Second, support at the remote site can be increased by providing a surrogate for the instructor to supervise students and conduct laboratory activities. Third, technology can be used to increase the visibility of activities between sites to achieve a greater degree of remote presence for the instructor. A combination of these approaches would offer the best solution for most courses.

Several other approaches are possible in specific circumstances. Probably the least acceptable alternative is to eliminate a laboratory from a course, or to segment the course so that lectures and laboratories are in different courses. Another problematic solution is to conduct the laboratory portion of the training on the job instead of in a formal training course. A related practice is where an instructor travels to a site to use existing equipment for training. Another solution is to conduct the course laboratory off-line within the VTT classroom or in another suitable space with the part-time assistance of a local subject-matter expert or a trained VTT facilitator. Finally, in some circumstances the audio and video services of the VTT classroom could be extended to an actual laboratory space for the purposes of conducting an instructor demonstration or a student laboratory.

These alternative approaches require case by case examination of course details to develop the best solution for each course. The best solution may result from a willingness to accept new alternatives and to engage in some experimentation. Resistance to converting courses to VTT is occasionally encountered and it is more likely when addressing the greater challenge of delivering a laboratory course. The following discussion involves a combination of the first set of alternatives (i.e., where better prepared students conduct laboratory work while being monitored over the VTT system by an instructor who is assisted by a remote facilitator who is physically present to supervise laboratories). The discussion documents the lessons learned from the courses studied and is directed at illustrating several techniques that might be generalized for adapting other laboratory courses.

### Preparation, Aiding, and Augmenting

There are several ways to better prepare, assist, or augment students for conducting their own laboratory work with less support from the instructor. These include: (1) enhance lectures and demonstrations given prior to the laboratories, (2) present instruction prior to laboratories by videotape or by computer-based instruction, and (3) provide a job performance aid to assist students during the laboratory. Several of these techniques can be used together. A combined approach was illustrated in the Fiber Optic course where videotapes were used to demonstrate cable repair, and computer-based instruction and enhanced preparatory lectures were given prior to trouble-shooting.

**Preparatory Instruction.** Information conveyed during interactive exchanges in traditional laboratories can be developed into an explicit instructional segment given prior to the laboratory in order to better prepare students for performing more work on their own. The idea that students can do work on their own would seem to highlight the weakness of using the VTT system. Although designed to benefit VTT remote students, this approach is merely an extension of good instructional practice applicable to VTT and non-VTT classes alike.

When an instructor is distant from students during laboratories the normal interactive exchanges and one-on-one adaptive forms of instruction are difficult to accomplish because the instructor cannot circulate among the remote students. Activities that may be difficult to accomplish over the VTT network typically involve interactive back and forth exchanges in front of equipment. For example, successive adjustments to test equipment may be made while laboratory participants share a view of the same screen, point at events on the screen or equipment controls, and engage in interactive exchanges to achieve an understanding of the procedure. In the Fiber Optic course, it was not uncommon for additional learning to take place in instructor-student exchanges during a performance test involving trouble-shooting and test equipment operation. The inability of the instructor to circulate among remote-site students in the normal fashion focused attention on developing alternative ways to provide this assistance. It became apparent during early class convenings in this course that the help sought on several topics could be lessened by explicitly presenting important aspects of the assistance normally given during the laboratories. Lecture material and demonstrations were enhanced to address problems previously observed during the test equipment and trouble-shooting laboratories. This material was then presented prior to the laboratories to prepare remote-site students for performing work more independently in the absence of an instructor within the room. Following this enhanced preparation for the laboratories, instructors judged that difficulties encountered by students were lessened during later classes.

A similar interactive situation existed in the computer laboratories of the Quality Assurance course. Some information normally conveyed in interactive exchanges while learning to operate a computer program was used as part of an instructor demonstration that was developed to prepare students prior to the laboratory. During the laboratory, student problems were resolved by the instructor while showing his computer screen over the VTT system so that they shared a common view of a concrete example during instructor-student exchanges.

**Use of Videotapes.** Videotapes can be used as an alternative to a live demonstration, to complement the demonstration, and as a primary form of instruction to prepare students for a laboratory. The ultimate rationale for these uses of videotapes is to ensure that remote students receive the best possible views of the demonstration in the event that detailed views and critical aspects of a live demonstration are not shown reliably. Videotapes can be used to reduce the demands on the instructor and may allow a more elaborate demonstration through various production techniques, such as editing to present the best views of equipment. A short demonstration can be presented by videotape when there is some difficulty in performing the demonstration live because it is difficult to recreate, or when there are constraints due to the size, angle, lighting, or hidden interior parts of objects. When short segments are used for a specific demonstration purpose, a videotape need not involve an expensive production. A low-budget depiction of only parts of a demonstration can be used to show views that normally require extra effort to display. These various uses of prepared materials can standardize the content and quality of the instruction. Videotapes provided for self-study by students also allow material to be reviewed several times and at a time and place that is convenient (cf. review in Wetzel, et. al., 1994).

**Computer-based Instruction.** As with videotapes, computer-based instruction can be used to prepare students for a laboratory as well as to provide other stand-alone instruction. Computer-based instruction offers a more interactive approach than does videotape. However, the software must support the student and impose minimal requirements for learning a computer skill. This approach was used in the Fiber Optic course by presenting fiber optic trouble-shooting problems prior to hands-on trouble-shooting laboratories. The inability of the instructor to circulate among remote-site students to provide assistance focused attention on the need to better prepare students for trouble-shooting with a simulated experience.

**Job Performance Aids.** Job performance aids are another way to augment remote site laboratories to compensate for less direct support from a distant instructor. Many existing student guides and job performance/assignment sheets are designed to provide guidance for students as they conduct their laboratory work. However, if students are to perform more independently, then these aids need to be carefully evaluated for self-sufficiency and revised to better support the student. Experience with actual students should be used to develop supplements and enhanced materials that address important missing points, common problems previously encountered by students, and important tips normally conveyed by the instructor during the laboratory. In some cases an aid may have to be developed because none exists. Laboratories on equipment operation may use a set of printed instructions or steps that can be enhanced to capture the expertise normally provided by the instructor during the laboratory. For example, some feedback provided by the instructor may be developed in the form of checklists so that students can verify for themselves that the steps of a task have been completed. A performance aid documenting correct plotting conventions was suggested for the Celestial Navigation course because remote students were at a disadvantage in not having an instructor circulating during laboratories to provide corrective guidance when these techniques were observed to be deficient. A similar support mechanism capturing the expertise of the instructors was developed to allow remote site facilitators to score student plotting on an examination by using an acetate overlay with the correct plotting information.

**Facilitator, Site Support Logistics, and Portability**

Delivering many laboratory courses by VTT would require somewhat greater efforts on the part of site personnel and would involve additional logistics support for the array of equipment and supplies required. These liabilities are not insurmountable for many courses, but each laboratory course needs to be considered on a case by case basis.

**VTT Facilitator.** The remote site facilitator plays an important role in supporting VTT courses. Normally, the facilitator is present during portions of a class, is the technical expert on the operation of the VTT system, operates cameras and other equipment, prepares the classroom, distributes class materials, serves as a test proctor, and scores examinations. The facilitator typically has little subject-matter expertise in the courses being delivered. Delivering student laboratories by VTT would increase the demands on the facilitator and would require a somewhat greater role for the facilitator during the delivery of these courses. Several areas of concern that could impact the facilitator are discussed below: supervision, safety, certification, subject-matter expertise, laboratory equipment logistics, and the behavioral role of the facilitator in assisting students and the instructor. Not all of these concerns would necessarily apply to a particular course.

Many laboratory courses would require that the facilitator be present in some or all laboratory sessions. This presence might be for general supervision of student activities and to maintain progress in some courses. In other courses, this presence would be required as a safety monitor because of electrical, chemical, or physical danger. For example, students would have to be monitored to ensure that they wore eye protection, were careful with liquids, and properly controlled tools and power sources. These issues would not prevent courses from being delivered by VTT if the facilitator were present during laboratories to warn students who disregard safety.

The facilitator would play an important behavioral role in many laboratory courses. The facilitator serves as an intermediary by acting as an agent of the instructor and by acting on behalf of students. The facilitator can serve as the eyes and ears of the instructor for on-going activities that are not visible or audible to the instructor. The facilitator supervises students and can inform the instructor of student progress or problems observed within the remote classroom. The facilitator also acts on behalf of the students by redirecting their questions to the instructor or by soliciting instructor assistance for observed problems. In the Fiber Optic course, the physical absence of the instructor and the physical proximity of the facilitator often led students to initially direct their requests for help and assistance to the facilitator, who then redirected them to the instructor. Several of the evaluation studies also suggested a trend in which remote site students were more likely assist one another. Thus, students may tend to rely on resources within their remote site, including other students, prior to using the two-way audio-video VTT system to consult with the instructor.

Somewhat greater logistical assistance would be required of facilitators because of the additional equipment used in some laboratory courses. This could include operating small portable cameras, and providing assistance when student work is shown to the instructor on these cameras or via the document camera. During laboratories, the facilitator might have to prepare, configure, or operate some equipment so students could perform their work. The facilitator might also have to serve as a proctor for performance tests and setup or restore test problems, such as prearranged faults for trouble-shooting. As in other VTT courses, providing remote sites with a detailed list of daily course events would ensure that materials and equipment are ready at the appropriate time. The logistics of conducting some laboratory activities might also result in slightly longer class periods at remote sites, as was observed in the Fiber Optic course.

Several of these support functions suggest that facilitators would be required to be somewhat more knowledgeable of course content than is usually the case. Courses that require certification of students would demand that some solution be devised. For example, the facilitator could serve as an instructor surrogate if the need for extensive subject-matter expertise could be minimized by training the facilitator in a very specific set of criteria documented in a well designed checklist. Alternatively, subject-matter expertise from personnel at remote commands could be used in a limited way for specific laboratory periods. In some cases, a facilitator could take a course as a student to become acquainted with the course procedures. However, it should be noted that recurring issues for the CESN concern how much skill facilitators should have in the content of the various VTT courses and how much time they have available when performing the facilitator role as a collateral duty.

**Site Support Issues.** There would be somewhat greater logistical demands on both local and remote sites to deliver many laboratory courses by VTT. A facilitator would be required to setup a room with course equipment and then store it away following a class. Additional storage space for course equipment at a site would be required between class convenings. There would also be a somewhat greater demand on the resources of the remote site to maintain a stock of the various consumable supplies used in some laboratory courses.

A flexible classroom layout can accommodate a variety of courses and would enable laboratory courses to be delivered with less difficulty. Greater classroom space is the primary factor in accommodating demonstrations and laboratory equipment used in this kind of training. There is some variability in the size of current VTT classrooms. Laboratory activities could be better accommodated if future VTT classrooms were selected to provide somewhat greater space for equipment at the front and one side of the room and for student work areas within the room (cf. Simpson, et al., 1992; Simpson, 1993; Wetzel, 1995). Other room considerations for equipment oriented laboratory courses could include providing power to student work stations by using low-profile power cords. The electrical supply to VTT classrooms may also be need to be increased to accommodate additional equipment.

**Portability.** VTT classrooms must be used by a variety of courses. Setting up a VTT classroom for a laboratory course can be made easier if the required training equipment is portable or can be adapted to be portable. In the Fiber Optic course, fiber optic cable systems were installed on roll-away carts. This method can be used for a variety of training equipment in other courses. The assortment of other small items in this course also lent themselves to being taken in and out of the classroom (e.g., suitcases containing the cable repair kits). Other laboratory courses have been successfully delivered by VTT which involved less support and laboratory equipment demands. A fewer number of small items than used in the Fiber Optic course are routinely taken in and out of VTT classrooms in the Celestial Navigation course without imposing undue burden (cf. Wetzel, 1995) (e.g., four navigation publications and an array of small navigational equipment such as used during plotting). The computer laboratory in the Quality Assurance course was conducted successfully by using portable laptop computers linked to a laser printer via a wireless local area network that avoided a clutter of wiring in the VTT classroom. Simpson et al. (1992) also used portable roll-away training aids for demonstrations in a Damage Control Petty Officer course or used videotapes to replace live demonstrations.

### Use of Technology as an Aid[4]

Several technologies were explored during the project for their value in supporting VTT instruction.[5] Several themes were illustrated in the use of these technologies: (1) increase the visibility of activities among sites, particularly the remote site; (2) use technologies to assist students during laboratories or to better prepare students for laboratories; and (3) reduce demands on the instructor with the aid of automated technologies, such as those that avoid the need for a camera operator. The use of technology to prepare students for laboratories was discussed previously with regard to videotapes and computer-based instruction. Several technologies are suggested in the following discussion that are applicable to delivering laboratory instruction, or which constitute augmentations to VTT classrooms that are applicable to lecture and laboratory courses alike. Many of these would be of value for regular use within the CESN and several illustrate a theme of providing flexibility and portability that should be followed in future equipment acquisitions.

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[4]There is no implied endorsement for any of the commercial products mentioned in this report. In most cases there are alternative products that could have been employed and mention of these products simply documents the actual equipment used in the research. Product names and brands mentioned herein are trademarks of their respective holders.

[5]Several suggested technologies for CESN classrooms discussed here are summarized in Appendix A.

VTT classrooms are typically configured to support lecture-based instruction with several standard pieces of equipment. Large monitors are used at the front of the classroom for students to view instruction or to see participants at other sites. Monitors at the rear of the room allow an instructor to see both incoming and outgoing video. The classroom typically supports four outgoing video sources which are controlled by a hand-held remote or from an equipment control station at the rear of a room. A pan/tilt/zoom camera on the front wall of a classroom is used to show a view of students within the room and a similar camera on the rear wall of the classroom shows a view of the instructor at a podium. A videocassette recorder (VCR) allows tapes to be played or recorded. A pedestal-mounted document camera at an instructor podium is the primary device used to show instructional materials, consisting of hard-copy materials, transparencies, or instructor writing. Chalkboards or whiteboards are typically not present in these classrooms. Students are provided with push-to-talk microphones to reduce extraneous noise, such as private conversations, shuffling of papers, or moving books.

Laboratory courses generally require an expanded number of video sources to show a wider variety of activities that demand a flexible and portable arrangement. The Elmo brand document camera found in all CESN VTT classrooms works well for many demonstrations because it allows extreme close-ups of small items. However, there are many instances where objects are too large for the document camera and some form of camera must be taken to the object to be demonstrated. Large items may have to be placed on a table or installed on carts that can be rotated. A camera mounted on a tripod can create an obstruction unless demonstration space is sufficient or the tripod has been made portable with wheels.

Several camera configurations were used in the adaptation of the Fiber Optic course to explore their potential for aiding the instructor or increasing the visibility of activities at the remote site. This equipment configuration provides an illustrative example that could be tailored to suit other laboratory courses. As described below, this configuration included several small portable cameras, a switch to accommodate additional video sources, a special purpose video source, and an automatic switching system to show views of individual students.

**Expanding Video Sources and Portable Cameras.** Expanding the number of video sources available at the instructor podium was found to have great utility for increasing the flexibility of using a variety of video equipment. Several video sources were accommodated by attaching a manual six-input video switch to the instructor podium so that one of several devices could be selected as the outgoing video from that location (e.g., Panasonic WJ-220 or equivalent switch). Thus, the document camera at this location became one of several video sources. The other video devices switched from the podium were a Video Labs brand "FlexCam," a small tabletop Canon VC-C1 brand video camera, a video-based 35mm slide projector, and a video microscope. Providing such a switch at the podium is recommended for all VTT classrooms because it easily accommodates a variety of other equipment, such as a scan converter used to show computer screens.

Two different small portable cameras were found useful in the Fiber Optic course. One of these was a Video Labs brand "FlexCam" that was used to show the array of small parts lying outside the view of the document camera during instructor demonstrations. This device consists of a small camera that is mounted on a table-top pedestal via a flexible gooseneck rod that allows the camera to be easily positioned in a variety of directions. The camera was connected to a long cable so that it could be taken to other tables within the room to show student work or test equipment being used at a student workstation. This camera has subsequently been used in other classes for demonstrations showing large items that will not fit under the standard document camera.

Another small portable camera was beneficial because it provided preset pan/tilt/zoom positions that eliminated the need for a supporting camera person during instructor demonstrations. The Canon brand VC-C1 camera uses a hand-held remote that allows six preset pan/tilt/zoom setting to be stored in memory and these can be activated by pressing six buttons associated with each view. This camera was used during instructor demonstrations of electronic test equipment to switch among views of a display screen, the control knobs and buttons, and an overall view of the entire front panel of the equipment. The test equipment was also on display in the remote classroom during these demonstrations so that remote-site students could see details of the actual equipment.

**Views of Individual Students.** The view of students at the remote site is typically either a wide view of the whole classroom or a more restricted view of only part of the classroom. The wide view is generally not sufficient to see details of students. The narrow view requires some effort in that the camera must be zoomed by an operator and this improved view of fewer students is achieved only after a delay. For typical lecture-based classes the view shown of remote students may be more of a monitoring convenience for the instructor and has little impact (Simpson, et al., 1991b, 1993). However, the benefit of a full two-way video capability is much more important when conducting instruction involving hands-on laboratories or highly interactive small group processes. Technologies for showing better views of participants between sites are currently evolving. As described below, an automated approach to this problem that avoided the need for a camera operator was informally explored in the Fiber Optic course.

A video switching system was developed which allowed each of four student workstations at the remote site to be viewed when a student used a push-to-talk microphone. Four cameras were suspended from the ceiling so that each camera showed a view the width of a students' worktable. An automated video-switcher used the closure of a set of contacts in a push-to-talk microphone to switch the outgoing video to show the individual student workstation where that microphone was located. Although this system was not formally evaluated, it was apparent that it provided a better view of individual students at their workstations and it avoided manually adjusting a pan/tilt/zoom camera. An automated system like the prototype developed here would be of value at remote sites. This configuration also could have been used for a course with small groups to show a closer view of team members around a table. An alternative configuration with fewer cameras could be used to show alternative halves of the classroom so that student faces and expressions would be more visible over the system. These configurations would involve some effort to install and an additional expense for the CESN. Off-the-shelf technology using a single pan/tilt/zoom camera is currently available for this purpose (e.g., the Parker Vision CameraMan or equivalent). However, the movement shown in the views with this configuration could be slightly more distracting than the immediate "cuts" between views in the system used in the Fiber Optic course study (cf. general reviews of production techniques in Wetzel, et al., 1994).

**Special Purpose Devices.** Special purpose video devices could also be used or developed for specific requirements in some courses. For example, some equipment may already be supplied with video outputs that allow it to be fed into the VTT system, such as some test equipment. Other examples of special devices for difficult situations could include headsets with microphones for noisy environments, a helmet mounted camera for intensive hands-on work in inaccessible spaces, or specially mounted cameras for heavy workbench work.

Instructor guidance was important in the Fiber Optic course when students sought assistance in judging the adequacy of their connector work. This guidance was made possible in VTT by constructing a video microscope that allowed connector ends to be viewed over the VTT system from either the local or remote site. A high resolution video camera with a reversed zoom lens allowed up to 190x magnification to show about three quarters of a 2.5 mm diameter connector tip. The camera was mounted on a small optical table with a photographic X-Y positioner in front of a holder for the connector. The video microscope allowed fiber optic cable ends to be inspected remotely and was clearly a benefit in allowing all students to share a view of good and bad examples of connector work. This public view of the connectors circumvented the difficulty of verbally describing what was being seen in the traditional viewing scope that could be used by only one person at a time. Students gave the video microscope one of the highest ratings received on a questionnaire. Although not appropriate for use with the fiber optic connectors, several other inexpensive camera products are available for use with conventional microscopes and other optical viewers.

**Other Technologies.** Several other technologies that augment the capabilities of VTT classrooms can be briefly mentioned. One such device described later is a scan converter that allows computer screens to be displayed over the VTT system. This allows standard computer presentation software to be used, an approach that is replacing several conventional media such as transparencies and 35mm slides. A video version of a 35mm slide projector is available at some CESN sites and it is still useful in accommodating older 35mm slide material. A variety of special purpose furniture is also useful in VTT classrooms, particularly when it is mobile to allow the rooms to be used in a flexible manner. One item of furniture found useful at the San Diego site was an instructor podium with a glass viewport in the top surface. This configuration allows a monitor contained within the podium to be easily viewed while graphics are being positioned on a document camera that sits atop the podium.

The equipment configuration used in the Celestial Navigation course may prove useful in circumstances where an instructor is off-screen for lengthy periods or where the instructor must move around beyond the podium area. A early version of the Parker Vision brand CameraMan device was used. This pan/tilt/zoom robot camera tracks a small infrared device worn by the instructor in order to maintain a continuous image of the instructor centered in the view shown by the camera. This view of the instructor was shown in a picture-in-picture panel in the right third of the outgoing video screen and the instructor's visuals and handwritten computations were shown in the remainder of the screen. These two images were combined by using a video mixer. The video mixer has also been used for other applications where it was desired that two camera sources be shown simultaneously (e.g., two participants viewed by different cameras or from different VTT sites). Such a mixer could be used at transmitting VTT sites that regularly originate instruction.

Emerging technologies may enable VTT to be extended beyond the current CESN classrooms. There may be opportunities to export the audio-video facilities of the VTT classroom to other environments if the spaces were nearby. For example, laboratories containing equipment too large to transport to the VTT classroom could be connected to the VTT classroom by a fiber-optic relay device to extend the incoming and outgoing audio-video lines to the laboratory. Another rapidly emerging possibility is the interconnection of VTT classroom sites with shipboard sites. Small computer-based workstations with audio-video facilities are being experimented with on-board ships. These workstations could also be used at small commands that are at remote locations.

**Use of Computers in VTT.** Computers are increasingly used in many courses which could be delivered by VTT. Issues with delivering this instruction by VTT include the way that computers are used in the training, instructor demonstration techniques, assisting students, and logistics.

Two broad categories of computer use can be distinguished that differ in how easily the activity can be conducted by VTT. Using computers to deliver instruction to students presents less of a difficulty than when the student activity involves learning a computer skill. When computers are used as a mechanism to deliver information or instruction, the software generally supports the student rather than an instructor. Examples are not limited to computer-based instruction. Computers are also used as information delivery or resource mechanisms in the case of interactive electronic technical manuals (IETM) and with other large sources of information distributed on CDROMS.

Training that involves learning a computer skill is more challenging when VTT students are distant from the instructor. The skill required to operate a software program varies with the specific details of the program and the training may require interaction with an instructor to resolve problems. As with other hands-on laboratories, the physical presence of the instructor is a benefit when this interaction involves activities such as pointing at portions of a screen or seeing sequential changes in a program when resolving problems. A perception that there was need for such student-instructor interaction played in a decision to not attempt a VTT conversion for one high throughput course (i.e., Communications Security Material System (CMS)). Some instances of learning a computer skill could be delivered by VTT more readily than others if the software is not very complex or if students have some prior experience. However, some enhanced preparation of students prior to their laboratory would be recommended to reduce the need for help when the instructor is distant.

There are several limitations with using computers in VTT. The resolution afforded by the video transmitted over a VTT system is less than that of computer displays. Additionally, video cameras cannot be readily used to show most computer screens without revealing a crawling band across the screen due to the frequency mismatch of these two devices. The scan rates for some laptop computer screens do not cause this problem, but they can cause reflections from lighting within the room and be difficult to position in front of a camera. One readily available solution for using computers in conjunction with VTT is a video scan converter (i.e., to convert computer VGA video to NTSC video). The resolution of the computer display is reduced when converted to NTSC video, but this device has still been found useful for several purposes in VTT classes. In addition to software demonstrations, virtually any of the many computer presentation programs that are available can be used. A scan converter is recommended for any CESN classroom where instructors present an electronic slide show or where visitors for teleconferences bring such materials on laptop computers.

Instructor demonstrations of application programs that students are to learn may have displays that cannot be altered to increase the visibility of details (e.g., diagrams or the size of text). A scan converter may also be used in these instances, but the demonstration techniques used by the instructor may have to be adapted to compensate for the loss of detail shown over the VTT system. In this circumstance, the displays may be for orientation purposes. An accompanying verbal description would be required to identify details and to point out the important aspects of changes to the screens being displayed. This orientation technique was used by instructors in the Quality Assurance course while demonstrating the sequence of operations for a program used to generate a report. Material with low legibility was described verbally and the instructor described steps to be shown prior to executing commands so that student attention could be focused on the change when it occurred. During laboratories when students had questions on a segment of the program, the instructor located that segment on his computer and showed it over the VTT network so that both sites shared a common view while discussing that part of the program.[6] A similar orientation technique was used in the Celestial Navigation course for small print tables in nautical publications. Critical portions of the text were placed within "bubbles" containing enlarged text and arrows pointed to where that entry was located on the page so that students could locate entries in their own publications.

Using computers in VTT classrooms presents several logistical problems. A VTT classroom must be used for a variety of courses and the installation of computers hampers the ability to share the classroom. Desktop space could be preserved for other classes by installing computer desks with a glass desk top that allows the user to view a monitor mounted within the desk. However, the size of these desks reduces the number of student seats per room compared with the desks now used for lecture classes. Additional wiring for this equipment would also be required. An alternative solution to this problem was tested in the Quality Assurance course computer laboratory. Laptop computers were used because they were portable and could be taken in and out of the classrooms. A wireless local area network (LAN) for printing documents was used to avoid the installation of wiring within the classroom.

Portable computers are recommended for other computer classes to avoid modifications to existing CESN classrooms. A more elaborate computer laboratory could be developed for VTT classrooms if there were sufficient demand to warrant the expense and logistical difficulties associated with a permanent installation. A wireless LAN would not be required if a single LAN wiring path were installed. This wiring could remain in place and the benefit of being able to remove the portable computers when other courses used the classroom would still be realized. More ambitious computer laboratory configurations could be developed if the demand for this capability were to grow in the future. For example, a data network could be installed in parallel with the VTT system to allow local and remote site computers to be internetworked (e.g., data could be shared between sites, student work could be inspected remotely, or remotely operated

[6]A scan converter could also be used to show the screens of remote students back to the instructor, but connecting student computers to the device may create logistical problems that could outweigh the benefits when student-instructor interactions are relatively brief.

programs could be displayed in a higher resolution than that supported by the video of the VTT system).

## Course Characteristics and VTT Delivery Difficulty

Four profiles of course characteristics will be described which represent degrees of difficulty in delivering training by VTT. Lecture-based instruction currently delivered by VTT is at one extreme, and at the other are laboratory situations that are prohibitive to consider for VTT delivery. Between these two extremes are two laboratory situations where training could be delivered by VTT, but which differ in the amount of effort required to convert and deliver the instruction. These have been termed “mild” and “moderate” difficulty laboratory situations. These profiles differ in the extent to which they would impact the present operation of the CESN. It is possible that the individual characteristics found in a specific course may span more than one of the profiles. The characteristics listed below may be useful in evaluating the feasibility of delivering courses by VTT.

### Typical Lecture-based Courses

The following course characteristics are typical of those found in lecture-based courses currently being delivered by VTT.

- The training is primarily instructor-centered and involves lecture-based material.

- Video is used primarily for showing the instructor and the instructor's training materials. Audio is the primary two-way medium.

- Visibility of remote-site students is more for general monitoring than it is for observing details, such as seeing student expressions, inspecting student work, or for supervising activities, safety, or certification.

- Instructor materials are paper, slides, or transparencies that can be presented by a document camera, 35mm video slide projector, or computer-based presentation program. Adapting these materials for VTT primarily involves revisions to accommodate these media to the lower resolution of video.

- Materials brought into the classroom are small, portable, and are not extensive; such as paper handouts, books, and manuals.

- Demonstrations are minimal or not demanding. Laboratories are typically for in-class exercises and homework that are performed by students with minimal need for physical presence of instructor to provide assistance.

- Interaction and assistance to students is primarily verbal. Document camera may occasionally be used to inspect student work.

- Subject-matter expertise at remote sites is minimal.

- Supervision of students is minimal and can be handled over the network or by the facilitator. Facilitator presence in classroom may be occasional.

- Testing can be supervised and scored by the facilitator. Scoring of tests is straight forward and requires little expertise on the part of the facilitator.

- Cost saving are related to having selected courses with a sufficient numbers of students, course convenings, class size, and a course of 5 days or less that allows more courses to be given.

- Costs for remote-site materials are for duplicates of local site paper-based materials and reflect a simple extension of the number of students.

**Prohibitive Laboratory Situations**

Attempting to use VTT for many laboratory situations would be prohibitive because they would require excessive conversion or delivery efforts, undue expense, or would be impractical because of adverse conditions.

- Subject-matter expertise is required at remote site beyond that which can be addressed by technological aids, a facilitator, or a semi-skilled facilitator.

- Supervision and safety are critical and require physical presence of instructor. Safety is of concern because of electrical, chemical, or physical danger. A specified instructor-student ratio requires multiple instructors.

- Certification is important or critical. The physical presence of a subject-matter expert is required and the certification function cannot be performed by a remote site.

- Visibility of students is critical and requires the physical presence of an instructor. Students cannot be adequately prepared for independent work prior to performing a laboratory and the physical presence of an instructor is required for active monitoring during the laboratory.

- Full scale equipment or an extensive system mock-up is required for the training. It is fixed at a location and cannot be moved, made portable, decomposed into smaller units, or simulated in some manner. Equipment is too cumbersome and expensive to duplicate at a remote site.

- Computers used in the training are too large, heavily entrenched, or expensive to be relocated to VTT a classroom. The computers are used to learn a complex skill requiring intensive interaction between instructor and student.

- The laboratory situation involves physical constraints. The use of cameras and audio equipment would obstruct the ability to move around and perform tasks or would disrupt the training activity itself. The environment involves excessive noise, poor lighting, a limited ability to see the interior of equipment, and a need to be unhindered by VTT technology.

- Cost considerations are prohibitive. Equipment or supplies are expensive and prohibitive to duplicate at remote site. Number of students may be small or constrained by access to laboratory equipment.

**Mild Difficulty Laboratory Situations**

Some laboratory courses are feasible to deliver by VTT with little inconvenience to the operation of the CESN. Converting and delivering these courses by VTT would involve a mild degree of difficulty relative to the lecture-based courses currently being delivered by VTT. Existing facilities would generally be sufficient to support these courses.

- Requirement for subject-matter expertise at remote site is minimal and facilitators can be trained in specific procedures used during laboratories. Subject-matter expertise can be addressed with job performance aids for students and aids that capture expertise required for facilitator to score tests or conduct laboratories.

- Compensating instructional techniques or technologies already exist or require some improvement to support relatively independent performance of laboratory work by students working on their own (e.g., job performance aids, preparatory instruction).

- Student laboratories can be given with minimal supervision of students by instructor or facilitator. Safety monitoring and student certification are not an issue in the course. Visibility of students is not critical.

- Physical presence of instructor is not critical to assisting students because students can perform laboratory work relatively independently. Students can get assistance verbally over the network, through occasional use of existing document camera to show student work, and students may assist one another.

- Interaction can be maintained by behavioral techniques used by the instructor, such as encouraging student questions and use of the system, and using a variety of preplanned questions directed at the remote site or to individual students identified from a roster. A group view is sufficient to observe students between sites.

- Some small group activities may be accommodated by appointing remote-site discussion-group leaders or by occasional monitoring by a facilitator. The teams can use the VTT system to report the results of group activities or discussions at the end of the activity for critique purposes. The team activities need not be observed or heard extensively during the activity and can be monitored occasionally with existing pan/tilt/zoom classroom camera.

- Demonstrations can be performed under a document camera or in front of the instructor camera. Details of the demonstration show well or may not be required. Students can be provided with copies of detailed graphics so that graphics used in demonstrations are primarily for orientation purposes. Demonstrations or laboratories that do have taxing requirements are short and not a major portion of course.

- Logistics are not a prominent concern because training equipment is portable and training materials are not extensive. It is possible to provide duplicate equipment and instructional materials at the remote site without undue expense. Demonstration items can be provided to allow remote students to see or manipulate actual objects.

- Computers used in laboratories are for instructional delivery, for acquiring or inspecting information, and the software supports the student. If computer software skills are learned, they are minor or not complex. Demonstrations of computer screens can be shown with a scan converter to provide general orienting and sequence information without exacting detail and can be supplemented by verbal descriptions.

- Cost considerations are not substantial because sufficient student throughput is anticipated. Laboratory materials or equipment are not costly and their availability does not constrain the number of students served.

**Moderate Difficulty Laboratory Situations**

Some laboratories are feasible to deliver by VTT if greater effort is devoted to support the delivery of the course. There would be an impact on the current operation of the CESN in terms of the demand placed on its resources. These laboratories are feasible if more effort is devoted to course conversion, adapting equipment and materials, additional technology is provided, sufficient facilities are provided, and more attention is devoted to deliver the course with greater assistance from a remote site. The simplicity of delivering the course may be sacrificed as a consequence of using technology.

- Some subject-matter expertise is required at the remote site. It can be addressed with a semi-skilled facilitator, part-time assistance of local experts, or by developing supplementary aids. The level of skill for the facilitator is less than that of an instructor and is specific to tasks in the laboratory. Testing involving expert judgement or student certification would require developing new methods or aids to capture this expertise for the remote staff, or concerted use of the VTT system to show student work or performance to the instructor.

- New development of compensating instructional techniques or technologies is required to provide more extensive support to students performing laboratory work. Preparation of students prior to the laboratory can be developed in the form of videotapes, computer-based instruction, enhanced lectures, and tips on problems to be encountered. New technology can be introduced to assist in judging student work by showing it over the system, such as small portable cameras, cameras showing workstations, or a special purpose device (e.g., video microscope).

- Physical presence of the facilitator is required as a surrogate for the instructor because visibility of student activities is important. The facilitator is required to be present during a major portion of the course to manage the laboratory and serves as a safety monitor.

- Assistance and interaction during the laboratory requires a concerted effort to use the VTT system to meet training objectives. Much visual and verbal information may have to be shared between sites. Instructor behavior involves active monitoring of remote site students, directed inquiries about progress, coordination with the facilitator, and staying on camera to be available for requests for assistance. The facilitator actively monitors students, redirects needs for assistance to instructor, and assists with equipment configuration or operation. Compensating technologies and instructional techniques have been fully exploited to maximize independent work and reduce assistance required during the laboratory.

- Instructor demonstrations require development of new presentation methods, developing new or revised training aids and mock-ups, and require the assistance of technology. Limitations on the ability to deliver a live demonstration or to see the details or interior of equipment can be addressed by developing videotapes. Additional cameras may be required to show a demonstration. These should be used to assist the instructor without disrupting the demonstration, such as with portable cameras and a pan/tilt/zoom camera with preset settings for equipment demonstrations.

- Highly interactive small group processes that are thought to require monitoring during the activities would require developing new instructional strategies or monitoring technologies. VTT can easily be used when all sites participate together as a whole class at the end of group tasks. However, monitoring the audio and video during the activities of several small groups at remote sites would require additional technology and efforts by instructors to monitor multiple groups.

- Logistics are a concern because equipment must be taken in and out of a classroom, numerous items must be setup in room, equipment requires additional storage space, or duplicating equipment at remote site is an issue. Delivery of course is still possible because equipment can be adapted to make it portable. Room electrical requirements can be addressed and it is possible to provide sufficient space by rearranging or enlarging classroom to accommodate laboratory equipment, table space for student work areas, and for storage.

- Training involving the use of computers for learning a software skill would represent more of a challenge than when they are used as an instructional delivery mechanism. Learning to operate some software could demand an increased level of interaction with an instructor. Portable computers could be used to address logistical problems. Better preparation of students prior to a laboratory could address common questions, problems, and tips on program operation. However, the impact of fully addressing complex software situations to make them feasible by

VTT could involve the use of substantially more technology to allow distant participants to share views when resolving problems, the installation an additional data network between sites, or the selective part-time use of local expertise at a remote site.

- Costs must be scrutinized with more challenging laboratory activities because equipment is expensive to duplicate at remote sites, access to equipment may constrain the number of students, or the training typically involves few students. Sufficient student throughput may justify equipment costs or lower throughput may be justified when critical skills are in demand.

**Examples of Course Difficulty**

Several examples of courses can be cited to illustrate the mild and moderate difficulty laboratory situations described above. These situations differ in the degree to which there would be an impact on the current operation and configuration of the CESN. These examples are from the courses that were formally evaluated and several other courses which were considered for possible conversion to VTT during the research project.

The Celestial Navigation and Quality Assurance courses are examples of courses representing a mild level of difficulty. The Celestial Navigation course required many small items to be taken into the classroom and these were accommodated because they were portable. Graphics used for orientation purposes were redesigned and a picture-in-picture display allowed the instructor to remain on-screen during lengthy periods of on-screen computations. Instructor assistance could be handled verbally and scoring expertise was captured in an aid used by remote-site facilitators. The Quality Assurance course also allowed VTT classrooms to be shared by other courses because portable computer systems were used. The laboratory was also short, involved a computer skill that was not too complex, and students were able to perform the laboratory without excessive assistance. Problematic portions of the software were addressed in a demonstration used to better prepare students prior to the laboratory. The resolution provided by a scan converter was adequate for showing computer screens of the general sequence of the program and for orientation purposes when students sought assistance.

Navy Leadership training courses might be considered either mild or moderate difficulty courses depending upon how much remote presence for instructors would be acceptable in the VTT situation. Team activities that could be reported over the network at the end of the group activity represent a mild level of difficulty. However, monitoring individual teams during the group activity would involve a moderate level of difficulty because new methods and technology would need to be developed beyond that which currently exists. Additional cameras and a switching system at a remote site would allow individual groups to be monitored with a consequent increase in the load on an instructor to monitor both classes. In either case, the highly interactive nature of this training would require experience delivering the course by VTT in order to evolve new instructional strategies and instructor behaviors to encourage greater interaction and participation. Delivering the training by VTT might also be feasible were it possible to use a remote site facilitator for some specific instructor functions during selected activities in order to monitor the progress or content of the group conversations.

The Fiber Optic Cable Repair course represents an example of moderate difficulty because it was feasible to deliver the course by VTT, but only with greater difficulty and substantial preparation. Numerous pieces of equipment had to be brought in and out of the classroom and portable carts had to be created to allow the fiber optic systems to be used in the VTT classroom. Various preparatory techniques were introduced into the course in the form of videotapes, computer-based instruction, and enhanced lectures given prior to the hands-on laboratories. Additional cameras were introduced to allow equipment demonstrations and the remote inspection of student connectors via a video microscope. Delivery of the course and the investment in conversion efforts would yield marginal cost returns with the small number of students typically enrolled per class.

Other courses considered for possible delivery by VTT during the research project illustrate examples of situations with a level of conversion and delivery difficulty that was either moderate or bordered on being prohibitive. These courses were of interest because they were both challenging and appeared to offer sufficient student throughput. The majority of courses reviewed for potential VTT delivery at FTC San Diego were more lengthy than what is typically offered by VTT (up to five days) or were prohibitive laboratory situations.

An example of a physical constraint limiting the use of computers was a system used for administration of maintenance and material management (i.e., the SNAP II computer system). The system used at the time the course was examined involved a large rack mounted configuration with a set of hard-wired terminals that was entrenched within an existing laboratory so that it could not be moved. Portable laptop computers could have been used in lieu of stand-alone microcomputers in another relatively high throughput Communications Security Material System (CMS) course considered for VTT. However, a perception by course personnel that student-instructor interaction was needed played in a decision to not accept an experimental VTT delivery of the training when a computer laboratory was added to the course. Subject-matter expertise was involved in guiding students and for scoring a performance test with document tracking software that allowed alternative paths to achieve similar outcomes. The course would probably involve a moderate level of difficulty to develop expertise and assistance compensations appropriate to the software skill.

Laboratory equipment adaptations and supervision were issues in two other courses that were examined. A magazine sprinkler course involved the use of large mock-ups of a system of pipes and values during laboratories. A partial mock-up at a remote site might have allowed a limited laboratory experience on one portion of the system since different students operated on different portions of the system during the laboratory. However, creating the new training aid would have involved some effort and it would have required coordinated operation by the remote facilitator. A similar situation was involved in considering a basic course in boilerwater/ feedwater test and treatment certification. Cumbersome portable sinks could have been constructed that involved several logistical problems and storage. Additionally, support at the remote site was required to certify students and for safety monitoring while hazardous chemicals were used.

A few operator and maintenance courses are short and they might be feasible to deliver by VTT with some development work. However, these courses commonly involve electronic devices that are expensive and difficult to duplicate at a remote site (e.g., full size global positioning system devices such as the AN/WRN satellite navigation equipment). An approach similar to that used in the Fiber Optic course could be used if such equipment could be duplicated at remote sites. Each piece of equipment would present a slightly different problem as to whether cameras could be used to show views between sites and what compensatory aids could be developed to assist students.

Finally, there are other situations where unconventional approaches could be attempted. As noted earlier, laboratory courses normally considered too difficult to deliver by VTT could be converted to a course with mild requirements if laboratory activities could be conducted off-line by remote-site personnel, could be conducted on-board ship, or eliminated from the course. Some sites may also provide an opportunity to extend the audio-video facilities of the VTT classroom to a nearby conventional laboratory. The use of teleconferencing on-board ships is also an emerging possibility. Although only very short or highly serialized formal training courses would appear feasible because of the shipboard regimen, several forms of ship-to-shore consultation have drawn interest. These promising uses of videoteleconferencing involve medical consultation and training related consultation on equipment maintenance. Some of this consultation can be accomplished via workstations with video conferencing capabilities. However, some equipment maintenance could involve working in hostile environments that would require additional equipment that constrains the ability to work normally, such as mobile lighting, mobile cameras, and headsets to overcome background noise.

## Conclusions

The following guidelines summarize the important aspects of the foregoing discussion on offering laboratory courses by VTT.

- It is instructionally feasible to deliver some laboratory courses by VTT. Mild forms of laboratory activities can be delivered without undue burden on the existing operation and facilities of the CESN. It is also possible to use VTT for moderately difficult to deliver laboratory courses that are more demanding and which would impact the operation of the CESN. These more challenging situations are feasible if more effort is devoted to adapting the course, additional technology is provided, greater assistance is provided by the remote site, and more attention is devoted to instructional delivery techniques.

- The learning environment in traditional laboratories may need to be conveyed in different ways in order to provide the same learning experience to remote students who are not physically with the instructor. A combination of three approaches would offer the best solution for most laboratory courses delivered by VTT. First, students can be better prepared for performing laboratory work prior to the laboratory. Second, support at the remote site can be increased by providing a surrogate for the instructor to supervise students and conduct laboratory activities. Third, technology can be used to increase the visibility of activities between sites to achieve a greater degree of remote presence for the instructor.

- There are several ways to better prepare or assist students for conducting laboratory work when they are at a distance from the instructor and must perform more independently.

Topics taught during laboratories can be moved into enhanced lectures and demonstrations given prior to conducting laboratories. Students can also be better prepared through prior computer-based instruction and videotapes, and can be assisted during the laboratory with job performance aids capturing the expertise of the instructor.

- The VTT facilitator plays an important behavioral, technical, and logistical role in laboratory courses. The VTT facilitator would need to be present during many student laboratories to assist students and instructors. This assistance would be minimal in mild forms of laboratory courses, but in more demanding courses facilitator supervision would be critical, such as to act as a safety monitor. The facilitator would have to be more knowledgeable of the subject matter in many laboratory courses than is typically the case in the CESN. An increased use of facilitators can be accommodated with less effort to the extent that courses can be selected where these requirements are minimal or required for short periods on specific tasks.

- The training equipment used in laboratory courses must be adapted so that it is portable and can be taken in and out of classrooms used for other VTT courses.

- Laboratory courses conducted by VTT require somewhat larger rooms to accommodate demonstrations and other training equipment. Room power requirements and facilities should be examined to accommodate equipment used in laboratory courses.

- Logistical demands on VTT sites would be increased with some laboratory courses. The VTT sites would incur somewhat greater demands on their resources in terms of the logistics for preparing classrooms during each class convening, maintaining supplies, and storing equipment between classes.

- Technology can be used to aid instructors and students in laboratory courses by exploiting several themes: (1) increase the visibility of activities among sites, particularly of the remote site, (2) use technologies to assist students during laboratories or to better prepare students for laboratories, and (3) reduce demands on the instructor with the aid of automated technologies, such as those that avoid the need for a camera operator. Laboratory courses involve a wider range of activities that must be shown with a flexible arrangement of more video sources. An expanded number of video sources that could be switched at the instructor podium was found to be useful in accommodating portable cameras and other special purpose video devices. Instructor demonstrations that are difficult to conduct live should be videotaped.

- The configuration of a classroom should provide for optimal student viewing of the instruction and participants at distant sites. For typical lecture-based classes the wide view of students in a remote classroom may be more of a monitoring convenience for the instructor and has little impact. However, the benefit of a full two-way capability for video and audio would appear to be much more important when conducting instruction involving hands-on laboratories and highly interactive small group processes. Additional camera views of remote students and their work are beneficial in these situations.

- There could be some sacrifice in the simplicity of delivering courses as a consequence of laboratory activities and the use of additional technology. To the extent that new VTT technologies can be used to mimic a live classroom, instructors and students can behave in ways they are already familiar with from traditional classrooms (Simpson, 1993).

- An initial cost analysis should be performed to assess whether converting a laboratory course to VTT would be beneficial. Travel savings would be marginal for laboratory course that typically have a small number of students per class, such as when access to laboratory equipment limits the number of students. Other laboratory courses with greater throughput could be beneficial when delivered by VTT.

- Initial costs for enabling remote site laboratory capabilities can be a liability when course training equipment is expensive and development efforts are extensive.

- A systematic approach was outlined for converting lecture or laboratory courses to VTT that should be executed by a team of individuals representing subject-matter, videoteletraining, and instructional expertise (cf. Simpson, 1993). The techniques and lessons learned illustrated in this research can be generalized for application to other laboratory courses. A case by case analysis and some experimentation are needed to achieve the best approach for the specific requirements of each course.

- VTT courses with atypical requirements such as student laboratories should be given special attention to maintain a high quality VTT version of the course. Such attention includes monitoring remote-site student performance, conveying VTT lessons learned as remote site facilitators and instructors rotate in their assignments, and providing sufficient resources. These courses should be periodically monitored by individuals knowledgeable of course content, instructional, and VTT issues.

- New courses to be created for delivery in the traditional manner should be scrutinized for potential delivery by VTT. Those suitable to VTT delivery should be developed from the outset with materials and procedures applicable to the VTT format.

## Recommendations

The following recommendations are for the Chief of Naval Education and Training, and the CNET Electronic Schoolhouse Network.

1. The lessons learned documented in this report should be provided as background material for use in adapting laboratory courses to VTT.

2. The approach to delivering laboratory courses by VTT should include enhanced preparation of students prior to conducting their laboratory work, technology that increases the visibility of activities between sites, and supervision by a VTT facilitator in remote-site laboratories.

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# Appendix A

# Equipment for Use in the CESN

# Equipment for Use in the CESN[1]

The following equipment could be considered as a supplement to the standard equipment found in CESN classrooms.

- A manual video switch box at all instructor podiums to accommodate a wider range of video sources (e.g., for 35mm video slide projector, portable cameras, scan converter, etc.).

- Instructor podiums that allow a video monitor to be housed inside and which can be viewed through a glass viewport mounted in the top surface of the podium.

- A robot tracking camera to follow instructor movements via a device worn by the instructor. This device could be used in one room at a major site that transmits instruction on a regular basis.

- Picture-in-Picture capability for transmitting sites where an instructor may be off-screen for long periods while showing graphics (this configuration was used in the Celestial Navigation course).

- A video mixer to allow two video sources to be shown on same video output. For use in heavily used classroom at a site that transmits instruction regularly. The video mixer also requires preview monitors and two video switches.

- A video switching system would be useful at remote sites where student laboratories will be conducted. The outgoing video would be switched to show particular locations where a student push-to-talk microphone has been pressed. A pan/tilt/Zoom camera configuration supporting preset positions is an alternative (e.g., Parker Vision CameraMan or equivalent). The purpose of this system is to allow individual student workstations to be shown (e.g., hands-on laboratories), or to show small groups of students (e.g., courses involving small group processes, such as Navy leadership courses).

- An audio mixer would be beneficial for sites that transmit instruction or which have numerous microphones such as in the video switching system. An audio mixer allows more audio sources to be accommodated and provides greater control over audio levels.

- A variety of portable carts provide a more flexible arrangement within a classroom and allow demonstration equipment to be moved in and out of a classroom.

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[1]There is no implied endorsement for any of the commercial products mentioned in this report. In most cases there are alternative products that could have been employed and mention of these products simply documents the actual equipment used in the research. Product names and brands mentioned herein are trademarks of their respective holders.

- Small portable cameras can be used to show demonstration items that are too large for the typical document camera, items which are outside the view of the document camera, or for taking cameras to the equipment to be shown. The Video Labs brand FlexCam or an equivalent with extended power and video cables fills this function. The Canon VC-C1 camera or equivalent was found useful in demonstrations because it provides presets that reduce the need for a supporting camera person (these were used in the Fiber Optic Cable Repair course).

- Camcorder for developing videotaped instructor demonstrations.

- VGA-NTSC scan converter to allow VGA computer screens to be converted to NTSC video for transmission over the VTT system. This device is required for laboratory demonstrations of computer programs. The device also allows commonly available computer-based presentation programs to be used for instruction and accommodates conferences and briefings using this method of delivery. The device would be recommended for all sites.

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